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Participatory Design and Autism

Supporting the participation, contribution and collaboration of children with ASD during the technology design process

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Abstract

Child-computer interaction researchers are increasingly recognising the benefits of directly involving children in the design of new technology. This has resulted in the development of several design methods for involving children in the technology design process, using approaches such as Participatory Design (PD). More recently there has been a greater focus on involving children with diverse needs, as technology can often be particularly beneficial within the education of these children. One such group is children with Autism Spectrum Disorders (ASD) and in recent years there has been a sharp rise in the amount of technology being developed specifically for this population. However, the needs and preferences of this user group can differ from the general child population due to the specific characteristics of ASD, with these differences making it more challenging for adult designers to develop appropriate technologies. This thesis therefore seeks to establish the potential of using PD to involve children with ASD within the technology design process through the development of a new PD method, which aims to support the typical difficulties of children with ASD at the same time as utilising their characteristic strengths.

A qualitative approach has been followed in order to understand firstly the ability of children with ASD to undertake typical design tasks; secondly the degree children with ASD are able to participate in the design process; and thirdly the ability of children with ASD to collaborate within a design team. The results reveal that children with ASD can undertake typical design tasks, but some children may require additional support to generate and communicate their design ideas. It is shown that a flexible approach should be taken with regard to the involvement of children with ASD within the technology design process, and the importance of the adaptability of the adult's role in supporting the children's participation and collaboration is additionally highlighted. This research has led to the development of a new PD method, IDEAS, which is tailored to the specific needs of children with ASD through the incorporation of flexible structured and supportive features.

Publications

The work within this thesis has resulted in the following peer-reviewed publications:

Work from Chapters Three and Four has been published in:

Benton, L., Johnson, H., Brosnan, M., Ashwin, E.,and Grawemeyer. B. (2011). IDEAS: an interface design experience for the autistic spectrum. In CHI '11 Extended Abstracts on Human Factors in Computing Systems (CHI EA '11). ACM, New York, NY, USA, 1759-1764.

Work from Chapters Three, Four and Five has been published in:

Benton, L., Vasalou, A., Khaled, R., Johnson, H. and Gooch, D. (2014). Diversity for Design: A Framework for Involving Neurodiverse Children in the Technology Design Process. In Proceedings of the 2014 ACM annual conference on Human Factors in Computing Systems (CHI '14). ACM, New York, NY, USA, (in press).

Work from Chapter Five has been published in:

Benton, L., Johnson, H., Ashwin, E., Brosnan, M. and Grawemeyer. B. (2012). Developing IDEAS: supporting children with autism within a participatory design team. In Proceedings of the 2012 ACM annual conference on Human Factors in Computing Systems (CHI '12). ACM, New York, NY, USA, 2599-2608.

Work from Chapters Five and Seven has been published in:

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Chapter 1 Introduction

1.1 Thesis Overview

Autism Spectrum Disorders (ASD) affect over half a million people in the United Kingdom and result in impairments in social and communication skills as well as rigid thought processes, repetitive behaviours and intense special interests. Prevalence rates of ASD have been steadily increasing; however it is not known if this is due to the disorder becoming more common or an increased awareness of the condition and the inclusion of milder forms such as Asperger's Syndrome within the DSM-IV diagnosis criteria. ASD is thought to occur in around 1% of the population (Baird et al., 2006), with boys four times more likely to develop the disorder than girls (NAS, 2010). ASD is considered to be an 'invisible' disability, particularly for those higher-functioning individuals who are academically able, meaning their need for extra support is not immediately obvious. The Autism Act (2009) and Adult Autism Strategy (2010) also highlight the need for more services for this particular group, arguing that an assessment for additional support should not be denied on the basis of IQ (Aylott, 2011). There are currently numerous medical, emotional and educational interventions that seek to provide support for the various difficulties that an individual with ASD may encounter (Research Autism, 2012). Many of these approaches provide the greatest benefit if they are employed during childhood and technology is increasingly being seen as an important part of this intervention strategy (Goldsmith and LeBlanc, 2004).

There is a substantial cost to educating children with ASD in the UK, the annual aggregate national cost of supporting these children is estimated to be £2.7 billion (Knapp et al., 2009). A considerable amount of this contributes to funding specifically trained teachers and teaching assistants to provide the intensive individual support children with ASD require throughout their education. The incorporation of specially designed educational technology into the teaching of children with ASD could substantially reduce some of these costs, in addition to providing the children with beneficial learning experiences. Children with ASD are now becoming frequent users of technology partly due to the affinity many children demonstrate with computers (Moore et al., 2000, Williams et al., 2002, Stromer et al., 2006) and the benefits that technology can offer them. These benefits include the ability to repeat tasks and easily correct errors (Salomon et al., 1989, Williams et al., 2002) as well as greater predictability and fewer social demands (Millen et al., 2010a). Although it should be acknowledged that ASD does not automatically result in an affinity with technology and that nothing can be applied universally to the ASD population due to a high level of individual differences, there is much anecdotal evidence indicating that the latest technological developments could greatly improve the quality of life for many children with ASD (Rhodes, 2012, Cellan-Jones, 2012, Burns, 2012).

The recognition of the beneficial impact well-designed technology can have on this population has led researchers to consider the role and involvement of children with ASD in the design of this technology. Many researchers advocate the involvement of typically developing (TD) children in the technology design process (Druin, 1999, Druin, 2002, Nesset and Large, 2004) and TD children have been successfully involved for over a decade. Researchers believe that involving children in this way can be of benefit to the final technology outcome (Frauenberger et al., 2011, Frauenberger et al., 2012b) and also that involvement in the process can be beneficial for the child participants themselves (Druin, 1999, Good and Robertson, 2006, Hussain, 2010). Researchers are beginning to involve children with ASD more actively within the technology design process (Keay-Bright, 2007b, Frauenberger et al., 2011, Millen et al., 2011), but there is still much concern about their involvement due to their difficulties with communication and collaboration, which are skills typically involved in technology design sessions.

Although there is some limited existing literature that seeks to involve children with ASD more fully within the design process there are yet to be any comprehensive design methods that specifically support the participation of children with ASD within a design team. *The overall aim of this research* is to develop a new participatory design (PD) method that can enable the participation of children with ASD within the technology design process as part of a design team. This is undertaken by exploring ways to appropriately structure the design sessions and investigating how to provide tailored support for the individual needs of the child participants, allowing each child to make as full a contribution as possible to the technology design process.

This thesis has three key goals i) to explore the types of design *contribution* children with ASD are able to make, ii) to establish the level of *participation* in activities within the technology design process children with ASD are able to achieve and as part of this iii) to determine the extent of their ability to *collaborate* with others within a design team. There is a tendency amongst researchers in this area to focus on the ‘barriers’ to involving children with ASD in the technology design process and how to overcome their characteristic difficulties. Although these difficulties are important to take into account, this work seeks to additionally identify and use the strengths of children with ASD during this process. It uses a combination of research techniques including observations, design workshops, participation experience surveys and design output evaluations. A stepwise approach to this research has been taken, to enable specific factors to be fully examined before moving onto the next stage. This approach involves first assessing the children’s ability to undertake typical design tasks individually before moving on to explore the same tasks within a collaborative design environment. A series of studies examine the ability of the children to participate within different design activities, to collaborate with both adults and other children as well as to design and build prototype technology.

The remainder of Chapter One introduces and defines the key terms used within the thesis (1.2), provides the scope in which the research was undertaken (1.3), describes the research methods used (1.4), and finally provides an outline of the chapters that form the thesis, highlighting the contributions within each (1.5).

1.2 Definitions

Key terms and concepts used within the thesis are important to establish early on. The definitions have been divided into two categories, firstly those related to the field of ASD and secondly those related to the field of Child-Computer Interaction. This is not intended to be a comprehensive list and other key terms will be defined throughout the thesis where appropriate.

1.2.1 Autism-related Definitions

Autism Spectrum Disorders (ASD)

The term ‘Autism Spectrum Disorders’ or ‘ASD’ refers to a wide spectrum of pervasive developmental disorders, characterized by a triad of impairments (Wing and Gould, 1979, APA, 2000) and which include:

- Social interaction problems
- Communication difficulties
- Rigid and repetitive behaviours/interests

Individuals diagnosed with ASD all exhibit deficits in these three areas, but there can be differences both in the degree/intensity of the deficit and in the unique manifestations of the autism characteristics that result from these impairments. The autism spectrum ranges from low-functioning autism to high-functioning autism (HFA) and Asperger Syndrome (AS).

High-Functioning Autism (HFA)

‘High-functioning autism’ or ‘HFA’ refers those individuals diagnosed with ASD who have average or above average IQ, but have experienced a language delay in early childhood (Baron-Cohen, 2000a)

Asperger’s Syndrome (AS)

‘Asperger’s Syndrome’ or ‘AS’ is a form of ASD; individuals with AS also have average or above average IQ similar, but do not experience the language delays or communication abnormalities observed in individuals with HFA (Baron-Cohen, 2000a). However, there are currently plans to remove the term AS from the forthcoming DSM-V diagnosis criteria and instead use the term ASD to universally refer to all individuals on the autism spectrum (APA, 2012).

Typically Developing (TD)

‘Typically developing’ or ‘TD’ is a term often used to refer to children who are not on the autism spectrum. The National Autistic Society (2011) encourages the use of more positive language when referring to autism, including the use of ‘typically developing’ instead of ‘normally developing’.

1.2.2 Child-Computer Interaction Definitions

Child

Within this thesis the term ‘child’ is used to refer to both children and adolescents up to 18 years of age, in line with the definition of child in the UN Convention on the Rights of the Child (UNICEF, 2008).

Technology

‘Technology’ is a frequently used term that can refer to a number of different things and therefore it is very difficult to determine a precise definition. The Oxford Dictionary (2012) defines technology as “the application of scientific knowledge for practical purposes”. However, when the term is used within the field of computing it has a more specific meaning. Goldsmith and LeBlanc (2004) suggest that technology often refers to “electromechanical devices such as cell phones, video recording equipment, and hand-held, desktop and laptop personal computers”. The word ‘technology’ has become synonymous with the traditional screen, mouse, keyboard and computer software setup, but with the latest technological software and hardware developments in interaction techniques it can encompass a much wider definition.

Within the scope of this thesis the definition of technology is narrowed and refers to the software that can be used on desktop and laptop personal computers.

Technology Design Process
Within computing the 'design' phase typically refers to the stage of the software lifecycle following on from the analysis phase and preceding the implementation phase (Read et al., 2002). However, within projects involving users as participants in the design process this can also reference all of the phases that encompass the conception, development and production of a new technology (Guha, 2010). For the purposes of this research, the term 'technology design process' refers to all phases in which the participants can be involved during the design of the technology, which includes the generation and elaboration of design ideas as well as technology prototyping and development.

User-centred Design
'User-centred design' can be viewed as a general phrase to refer to the consultation of users at some point during the technology design process (Read et al., 2002) and can be used as an umbrella term for all design approaches involving users. It can also be used to refer to a design approach where the user is seen predominantly as the subject of the design process and has minimal opportunity to directly contribute towards the design decisions made during this process (Sanders and Stappers, 2008). The latter definition is the definition used within this thesis.

Participatory Design (PD)
'PD' is a design approach that actively involves users as participants throughout the design process (Rogers et al., 2011). It covers design scenarios where multiple stakeholders are involved within a collaborative democratic process (Read et al., 2002, Hussain, 2010), and where each stakeholder group contributes their own expertise to the design product.

Collaborative Design
The term 'collaborative design' or 'co-design' has recently been used interchangeably with PD by some researchers (Sanders and Stappers, 2008), but is believed to be a subset of PD by others (Walsh et al., 2013) where it is implied that the end-user is actively involved in the design process. However, within this thesis the term PD rather than co-design is used to refer to all design approaches actively involving end users within a democratic technology design process.

Structure and Support
This thesis frequently refers to the terms 'structure' and 'support' in conjunction with one another, and it is important that the difference between these two terms is made clear. In this context 'structure' relates to the environment and organisation of the design activities, whereas 'support' refers to the additional assistance provided by adults or tailored materials for individual design activities.

1.3 Thesis Scope

It is necessary to define the scope of this thesis in the context of both the autism spectrum and the type of technology.

The autism spectrum encompasses a wide range of individuals from those with low-functioning autism who are unable to communicate with the outside world to individuals with HFA and AS who can be intellectually very able. It is thought that approximately 45% of the ASD population have what is termed HFA or AS, and these individuals possess an IQ >70 (Baird et al., 2006). A small proportion of these individuals are referred to as 'autistic savants' and exhibit an unusually high level of a specific ability. This work initially focuses on children with HFA/AS aged between 11 and 14 years, to ensure the children are able to verbally communicate their ideas and opinions during the design sessions, which will help in developing an appropriate PD method. However, it is hoped the outputs from this thesis will potentially be adapted in the future for low-functioning children.

As discussed in the previous section technology can encompass a wide range of hardware and software. This thesis concentrates on the design of educational software for use on a desktop or laptop personal computer. The design task is focused on the design of the visual display rather than any physical interaction techniques. Within the introduction to this chapter it was established that technology offers great potential as part of the education of children with ASD and therefore the work centres around designing educational technology, and in particular educational (or 'serious') games. Computer games form a significant part of children's culture (Kafai and Carter Ching, 1996) and this is common across both TD and ASD child populations (Mazurek et al., 2011). In relation to children with ASD, Grandin (2012) also believes in encouraging the use of games that "promote learning academic skills or social cooperation". Therefore it is hoped that by focusing the PD sessions initially on the design of educational games this will ensure that the design task is appealing, not becoming another 'barrier' to the participation of children with ASD, and also has the potential to result in an outcome that is beneficial to the education of this population.

In summary, this thesis is scoped to examine:

- Involvement of children with HFA/AS aged 11-14 years in technology design process through a PD approach
- Educational game design and any wider implications for educational technology

The following section will briefly introduce the research methods used within this thesis.

1.4 Research Methods

Within the thesis a research approach, which contributes to the development of new design methods, principles and guidelines, has been undertaken. A range of different data collection and analysis techniques were chosen, dependant on the research questions being asked. A predominantly qualitative approach has been taken to enable a detailed exploration of the rich data set resulting from this work. Several data collection approaches were employed including field and questionnaire studies. The field studies were undertaken to evaluate the utility of the design method developed through this research at various stages within the process. The initial study was documented through written observational notes whilst the later studies were documented by video recording and transcribing these videos after the sessions. The questionnaire studies were firstly used to establish the opinions of the study participants in relation to both the final output and participation experience. Questionnaires were also used with *non-participant* children within the participant children's wider peer group to evaluate the final outputs. The 'fun toolkit', a collection of survey instruments designed specifically for use with children (Read and MacFarlane, 2006) was modified for the context of this research and used during the questionnaire studies. Each of the different data collection approaches involved both a group of children with ASD and also a group of age, gender and verbal IQ matched TD children to act as a comparison group.

One of the key qualitative analysis techniques employed within this thesis is that of thematic analysis. Braun and Clarke (2006) describe thematic analysis as a "method for identifying, analysing, and reporting patterns (themes) within data". Thematic analysis was chosen as it is a flexible technique, which allows for a number of analytical approaches to be taken. In this case a 'theoretical' or deductive approach was chosen to enable the data to be coded for specific research questions, which have guided this research. There are also several levels at which the analysis can focus upon and the analytic process undertaken here has concentrated on a semantic level. This considers the explicit meanings of the data to enable patterns to be identified and then theorises the implications of these patterns in relation to the existing literature discussed in the following chapter.

1.5 Thesis Outline and Contributions

This thesis is guided by the following broad research question: **How can the design contributions, level of participation and collaboration of children with ASD be best supported to enable their successful involvement within the technology design process?** This research question directs the review of existing literature and provides a structure for the remainder of the thesis.

Chapter 1 – Introduction
Chapter One has introduced the focus of this research, defined the key terms used within this thesis, established the scope within which this work has been undertaken and briefly outlined the methods used in order to conduct this research.

Chapter 2 – ASD and Children's Technology Design
Chapter Two reviews the existing literature within the research areas of ASD and children's technology design in the context of the above broad research question. It firstly outlines the current theories of autism as well as existing interventions employed within the education of children with ASD. Secondly work within the field of Child Computer Interaction is examined, focusing both on approaches to designing for children and designing with children.

The literature review identifies the many challenges faced by individuals with ASD, but also highlights the benefits of technology within educational interventions for children with ASD and the large amount of technology now being designed for this population. The review describes a number of methods that have been used successfully to involve TD children within the technology design process, but recognises that there are a number of barriers to involving children with special needs in participatory projects. The issues identified within this chapter form the basis for an initial set of more specific research questions that this work aims to address.

Chapter 3 – Children with ASD and PD
Chapter Three begins by examining the specific literature relating to the involvement of children with ASD in the technology design process. The various levels of participation this population have undertaken within previous work are identified in addition to the ASD-specific challenges that may impact the further involvement of children with ASD using a PD approach. It is established that children with ASD are still rarely involved in the design of this technology and there is not yet a PD method that specifically supports the participation of children with ASD within a design team. There is also little evaluation of the contributions children with ASD are able to make to the design of technology to establish if they are able to generate design ideas that appeal to their wider peer group. Additionally it is recognised that there are many issues with involving children with ASD more fully within the technology design process, but the precise level of participation they are able to undertake has yet to be determined. The set of research questions initially defined at the end of Chapter Two is refined and expanded based on the findings presented within this chapter.

The second half of this chapter proceeds to examine a number of existing design methods and techniques for TD children to determine their suitability for use with an ASD population. The results of this analysis are then used to inform the development of a new PD method, IDEAS, specifically tailored to the needs of children with ASD. This chapter ends with an outline of the empirical research undertaken within the thesis and the structure of the remaining chapters.

Chapter 4 – Study One: Individual Design Tasks

Chapter Four contributes to the understanding of the ability of children with ASD to undertake design tasks typically used within PD. The motivation for this is to identify if problems exist in undertaking the actual design activities, which could also exacerbate any communication and collaboration problems inherent in being part of a design team in the later studies.

Study One involved 20 children with ASD and 20 TD children individually participating in one-off design sessions. The children undertook design tasks from either an existing design method for TD children, or from the newly developed IDEAS methods tailored to the needs of children with ASD. It provides an insight into the ability of children with ASD to undertake typical design tasks with and without additional support. It also allows the level and type of support needed to enhance future participation in design team activities to be determined. It was important to establish this ability and level of support needed for design activities before introducing the collaboration element to ensure that an inability to collaborate did not become a barrier to participating within the design tasks. This initial study established that children with ASD were able to undertake these typical design tasks, but that some children required additional support in order to complete the activities successfully. Additionally the role of the adult within this support was highlighted, particularly concerning the need for the adult to undertake a number of different roles in order to support each child appropriately. The findings also raised several issues within the IDEAS method, which needed to be addressed in a further iteration to enable the method to be used with a design team over a period of time, and were addressed during the next study.

Chapter 5 – Study Two: Collaborative Design Contributions

Chapter Five builds on the understanding of the types of design contributions children with ASD are able to make within a collaborative design environment. It seeks to establish the ability of children to generate design ideas as part of a design team that both fulfil the design brief and appeal to their wider peer group. It also discusses the implications of these ideas in terms of the design of educational technology for an ASD population. Building on the findings from Study One and existing collaboration literature the IDEAS method is refined and trialled during an extended study.

Four design teams were involved in Study Two, with two teams of three children with ASD and two teams of three TD children. Both teams also incorporated two researchers and one teaching staff member. The differences in design contributions between the ASD and TD children were explored, revealing that the children with ASD required a wider range of structure and support from the adults to generate and expand upon their ideas. These ideas highlighted a number of potential implications for the design of educational technology including the careful integration of sound, additional support for reading difficulties and the need for explicit feedback as well as personalisation options. It was also established that the team design ideas of the children with ASD did appeal to a sub-section of their wider peer group, but the narrow special interests of some of the individual participant children had a negative impact on the likelihood of the design output having a more general appeal. Also it became clear that it was necessary for the adult researcher developing the prototype to undertake a certain level of interpretation of the children's original ideas. This indicated a need for the children to have a greater level of participation within the process to reduce the interpretative load on the adults and potential for discrepancies between the children's ideas and the prototype created by the adult researcher.

Chapter 6 – Study Three: Collaborative Design and Build Contributions

Chapter Six builds on the contributions from the previous chapter, in relation to establishing an understanding of the design contributions made by children with ASD within a design team. Study Three takes this further by increasing the children's level of participation within the design process by allowing them involvement within the build phase and assessing how this impacts the children's design contributions. It examines the effect this greater level of involvement has on the appeal of the final output to their wider peer group. It also further discusses the implications of these design outputs for the design of educational technology aimed at an ASD population. Again the IDEAS method is further refined based on the findings from the previous study providing additional activity-based prompts to reduce the need for verbal prompting from the adults and to allow for the involvement of the child participants within the build phase of the process.

Four design teams were involved in Study Three, with the same team setup as Study Two and with one existing ASD team and one existing TD team from the previous study continuing their participation within this study as well as one new ASD and one new TD team. This enabled a comparison between the existing and new design teams. The findings from Study Three revealed that the children generally required less support to generate and expand upon their ideas than in the previous study, potentially due to the additional activity-based prompts in the form of design templates. These ideas had further implications for the design of educational technology, particularly in terms of the very specific graphical elements and 'fun' features the children wanted, which highlighted a need for customisation options to be incorporated. It was established there were differences in the appeal of the design ideas to the children's wider peer group in relation to the previous study, with the design ideas generated by one of the ASD teams being most appealing (and the design ideas generated by one of the TD teams being least appealing) to the group of non-participant children with ASD. This indicates that mitigating potential misinterpretation by adult researchers during the build phase may help to increase the appeal of the final design output to the children's wider peer group.

Chapter 7 – Participating within a Design Team

Chapter Seven contributes to the understanding of the level of participation children with ASD are able to undertake within the technology design process. It also determines the role the adults need to undertake to support this participation, the most effective techniques for engaging children with ASD within the process, and whether the children benefit from their participation, and in what ways. In order to establish these contributions the findings from Studies Two and Three were examined again, but this time within a different context to explore the children's level of participation during each study. The context in this case focused on the experiences of the different design team members rather than the design outputs, which was achieved through examining the actions of the participants as well as the feedback they provided directly through the post-participation questionnaires.

The analysis of these two studies revealed that the role of the adult was necessarily determined by the individual needs of each child participant, with the adult transitioning between several different roles during a single design session as well as across the series of sessions. This could be dependent on the design activities as well as other external factors. High levels of engagement were observed during the sessions across both studies particularly in relation to the demonstration or trialling of existing technology. However, an increased demand on teamwork skills within Study Three negatively impacted the engagement of the children with ASD within the more collaborative activities. This means more adult intervention was required in terms of facilitation and motivation, and could be due to the difficulties they can typically experience when working with others. Finally a number of benefits of participation were identified, indicating that in addition to having a potentially positive impact on the technology output, there may also be benefit to any children participating within the technology design process.

Chapter 8 – Collaborating within a Design Team
Chapter Eight contributes to the understanding of the ability of children with ASD to collaborate when working as part of a design team. This involved a re-examination of the findings from Studies Two and Three within a collaboration context, to further explore the collaborative activities occurring within each study and the specific structure and support for these activities. It also examines the roles and responsibilities that children with ASD are able to undertake as well as identifying collaborative behaviours demonstrated by the children and how they manage any collaboration difficulties.

The analysis of these two studies indicated that children with ASD do have the potential ability to participate within collaborative activities alongside other design team members. The children demonstrated abilities to undertake a number of roles/responsibilities within these collaborative design activities and transition between them during a single session. They were also observed exhibiting a number of different collaborative behaviours, which allowed them to successfully complete the various collaborative activities involved in Studies Two and Three. However, adult intervention was required at various points during the sessions when the children with ASD encountered particularly challenging aspects of the collaborative activity and they found it more difficult than the TD children to overcome these challenges as a team. This highlighted the importance of providing a structured and supported collaborative design environment to allow children with ASD the best opportunity to succeed within collaborative activities.

Chapter 9 – Conclusions and Future Work
Lastly Chapter Nine discusses the key findings, contributions and limitations of this research as well as describing further work that could be undertaken in the future. It is intended that the findings and conclusions formed within this chapter may be used by both developers of technology aimed at children with ASD and designers seeking to involve children with ASD within the technology design process.

A general review of existing literature within this research area will now be presented in the following chapter.

Chapter 2 ASD and Children's Technology Design

2.1 Overview

Technology is increasingly being seen as a beneficial intervention strategy in the education of children with ASD. This is due in part to a large number of children with ASD demonstrating a particular affinity for technology in addition to the removal of the social demands of classroom-based learning. However, it is difficult for neurotypical adult designers to predict and understand the specific needs of children with ASD. As has been established, one method for eliciting the needs of end users is by involving them throughout the design process using a PD approach.

The use of PD with adults is long established and TD children have also been successfully involved in the design of technology using PD for over a decade. There are far fewer examples of children with ASD being involved in the design process although this has been increasing in recent years. Francis et al. (2009) believe that excluding certain societal groups, such as individuals with ASD, from the technology design process may be detrimental, but there is currently little guidance or design practices to help designers successfully support the inclusion of children with ASD in this process. There is also little empirical evidence about if and how children with ASD could benefit from being included within the design of technology, both in terms of the process of participation and the eventual end product.

In this chapter the existing relevant literature from the fields of ASD and children's technology design is examined. The first half of the literature review focuses on the *typical characteristics* that define ASD and the prominent *theories of autism*, which give rise to notions about how to teach and also how to devise *intervention strategies* used in the education of children with ASD. The second half of the review proceeds to examine the *design of technology* for and with children in general as well as specifically for an ASD population. It considers current *design principles* for children's technology and their relevance for an ASD population. The review then explores the concept of *child participation* both in general and within the field of technology design. It discusses the *levels of involvement* and *various roles* children could potentially undertake within the design process, and considers the *balance of power* between the child and adult participants. This is followed by a discussion of existing PD methods that have previously been used with TD children. Finally the review concludes with a summary of the findings from the literature as well as a discussion of the outstanding issues within this area, and how they have influenced the definition of an initial set of research questions. These research questions provide a framework for the work within this thesis and are refined further within the following chapter.

2.2 Autism Spectrum Disorders

ASD encompasses a range of pervasive developmental disorders, from low-functioning classic autism to Asperger Syndrome and is thought to occur in around 1% of the population (Baron-Cohen, 2008). Approximately 45% of the ASD population are believed to have HFA or AS (Baird et al., 2006).

Leo Kanner and Hans Asperger first published accounts of childhood autism, independently, but within a year of one another. Both authors observed groups of children who exhibited unusual behaviours that corresponded to the three areas of what is now known as the triad of impairments. The triad includes peculiarities of communication, the inability to establish normal relationships with their peers, and particular stereotypical movements as well as varying levels of intellectual achievement (Frith, 2003). Both authors also emphasised the strengths of the condition such as "special skills, absorbing interests and strong rote memories" (Mesibov et al., 2001). Kanner believed the primary characteristic of the condition was the deficit in social skills and chose the name autism to highlight this central feature. Although there were many similarities between the two descriptions, Hans Asperger's group did not exhibit the same severe language delays observed in Kanner's group, they also had more motor deficits and were all boys. Furthermore, the authors interpreted parental involvement differently; Kanner considered that the parents' intellectual and cold manner may have contributed to the child's autism, whereas Asperger saw this behaviour as evidence for a specific genetic phenotype (Mesibov et al., 2001).

It was not until the pioneering work of Lorna Wing (Wing and Gould, 1979, Wing, 1981) that English speakers became aware of Asperger's paper (originally published in German) and the connection with the work of Kanner. Wing also undertook an epidemiological study of the children living in a South London borough, the results of which helped to establish the concept of the triad of impairments that characterise ASD (Wing and Gould, 1979). This triad of impairments incorporates difficulties with communication and social skills as well as rigid and repetitive behaviours and interests.

There are currently several theories that attempt to address the reasons for the primary deficits in ASD. Although some of these theories have overlapping notions, there is no single existing theory that alone can provide a neurocognitive explanation of the multiple deficits observed in ASD. It is important to consider these existing theories as they may have implications for the development of a PD method specifically aimed at an ASD population. The most prominent of these theories of autism are described below.

2.2.1 Theories of Autism

Each of the following theories of autism seeks to explain many of the core and peripheral aspects of the condition.

2.2.1.1 Theory of Mind (ToM)

ToM was developed in the mid 1980s by Baron-Cohen, Leslie and Frith (1985) and is one of the most well known theories of autism. Possessing a theory of mind is having the ability to reflect on the contents of one's own mind and also understand what others are thinking. This is an ability that individuals with ASD are said to lack (Baron-Cohen, 2008). This theory originated from the results of a false belief task, but Happé (1994) points out that 20% of the children with ASD were actually able to pass this task and so the theory could not be universally applied. Therefore Baron-Cohen later modified the theory stating that ToM was a delay instead of a deficit. Happé (1995) also found that this delay in ToM was associated with verbal mental age.

The exact definition and theoretical underpinning of ToM is still a contentious issue after more than 20 years of research and is now increasingly being referred to as "mind-blindness" rather than having a "lack of ToM" (Rajendran and Mitchell, 2007). One of the main shortfalls of ToM is that it does not explain the non-social features of autism such as rigid and repetitive behaviours and interests. It also focuses on the deficits of the condition, not taking into account the strengths frequently observed in individuals with ASD.

2.2.1.2 Executive Dysfunction (ED) Theory

Executive function is an umbrella term for behaviours which include “planning, impulse control, inhibition of prepotent but irrelevant responses, set maintenance, organized search, and flexibility of thought and action” (Ozonoff et al., 1991). Researchers noticed similarities between symptoms of a specific brain injury and autism, which included a need for sameness and repetition as well as problems switching attention and controlling impulses (Rajendran and Mitchell, 2007). This led them to believe that the executive function of individuals with ASD was impaired, which would explain non-social aspects of autism such as the dislike of change and the occurrence of ‘obsessions’ with narrow interests (sometimes in highly unusual areas such as toilet brushes, yellow pencils or road signs) seen in ASD. The ED theory can explain many features of autism, including both cognitive and motor characteristics. However, these difficulties are not unique to autism (also seen in Attention Deficit Hyperactivity Disorder, Obsessive Compulsive Disorder and Tourette’s syndrome) and again not all individuals show executive problems, there can be a range of different profiles (Rajendran and Mitchell, 2007).

2.2.1.3 Weak Central Coherence (WCC) Theory

The WCC theory states that individuals with ASD have a tendency to concentrate on the finer details of things, often struggling to see the ‘bigger picture’ and have an attention to detail that ranges from meticulous to obsessional. WCC can explain some of the social as well as non-social features of autism, but again is subject to a number of different interpretations, construing this detailed-focused nature in both positive and negative ways. It explains both having an excellent attention to detail, but also difficulties with generalisation. It is thought that individuals with ASD process the unique features of stimuli well, but common features poorly leading to problems applying newly learned behaviours to novel environments (Rajendran and Mitchell, 2007). WCC has now been recast as a cognitive style related to superior local processing (Happé, 1999), explaining one aspect of cognition in ASD.

2.2.1.4 Empathizing-Systemizing (E-S) Theory

The E-S theory was also proposed by Baron-Cohen and resulted from a need to explain the non-social features and specific strengths observed in ASD, but not accounted for by ToM. The E-S theory states that individuals with ASD have superior skills in systemizing (a drive to analyse or construct systems) but at the same time delays or deficits in empathizing (Baron-Cohen, 2009). The below average empathizing explains the social and communication difficulties individuals with ASD experience and the above average systemizing explains the rigid and repetitive behaviours and interests. Baron-Cohen (2009) states that it also has the power to explain “the uneven cognitive profile, repetitive behaviours, islets of ability, savant skills, and unusual narrow interests” found in ASD. The need to understand each different part of the system rather than being driven by WCC is instead due to a need to systemize, which could in turn provide an alternative explanation to the ED theory. A further extension of the E-S theory is the extreme male brain (EMB) theory, which provides an explanation as to why ASD is more prevalent among males, who typically demonstrate higher levels of systemizing than females, who show higher levels of empathy.

2.2.1.5 Summary of Theories

One of the major criticisms of these theories is that they have a very static view of the condition, and could benefit from taking a more dynamic developmental approach

(Rajendran and Mitchell, 2007). Manifestations of ASD can vary dramatically across individuals on the spectrum, but also change as each individual matures and therefore theorists plans to explain autism in its entirety may be unrealistic. Happé and Ronald (2008) believe it is important to treat each aspect of the triad independently otherwise something could be missed. There are vast individual differences in ability and behaviour within ASD, one key factor is the range of IQs observed across the spectrum, but there are also differences due to age, temperament, interests, and array of skills (Mesibov et al., 2007). The range of developmental levels and behavioural profiles mean it is important to take into account each individual's profile when considering interventions and treatments, with a "one treatment fits all" approach likely to produce "mixed results" (Happé and Ronald, 2008). Although it is a specific combination of deficits that is unique to ASD, there are overlaps with other disorders, which suggests any tailored interventions also may potentially benefit other populations.

2.2.2 ASD Interventions

An intervention can be described as an activity intended to enhance the quality of life of an individual with ASD, and could be a treatment, therapy or service provision (Research Autism, 2012). There are many types of intervention with a variety of different aims. Some focus on specific behavioural issues whereas others can be guided by theories of autism and address the core deficits of the condition, such as the TEACCH program (Mesibov et al., 2007), which is described in more detail below. The intervention strategy chosen depends on the unique needs of each individual, so there is no universal solution with the most effective interventions being customizable for the specific profile of characteristics and behaviours of each individual (Research Autism, 2012). Intervention approaches can range from prescribed or complementary/alternative medication to behavioural and developmental interventions and assistive technology.

Behavioural and developmental interventions are particularly applicable to children as they include "a large and diverse range of educational strategies, programmes and techniques" (Research Autism, 2012). Educational interventions are important for children with ASD as they can have an uneven profile of skills and knowledge, being particularly able in certain areas and having difficulties in others. Education is seen as key to enabling individuals with ASD to live as full and happy a life as possible (Moore et al., 2000) and previous studies have suggested "education may be considered as the most effective therapeutic strategy" for children with ASD (Konstantinidis et al., 2009). Mesibov et al. (2007) state that traditional educational methods are frequently insufficient for teaching individuals with ASD and so have developed an alternative approach as part of the TEACCH program, a widely used and internationally recognised educational program for individuals with ASD.

2.2.2.1 The TEACCH Approach

Over the last 30 years the Treatment and Education of Autistic and related Communication handicapped Children, or the TEACCH program as it is more commonly known, has been responsible for developing a theoretical model for understanding ASD (the Culture of Autism), which has resulted in a set of intervention strategies called 'Structured Teaching' (Mesibov et al., 2007). The aim of structured teaching is to develop the skills and understanding of individuals with ASD at the same time as adapting their environment to best support their particular needs and limitations. It is an individualised approach, and the type and level of instruction and support is specifically tailored to their particular skills, interests and needs. The Structured Teaching approach incorporates a number of different theoretical perspectives, which include some of the ASD theories described above such as the WCC and ED theories.

Mesibov et al. (2007) define structure as the "active organization and direction of the physical environment and sequence of activities". Research and clinical literature highlight the importance of structure for individuals with ASD, which helps to overcome difficulties with conceptual and organisational skills (Mesibov et al., 2007). Studies have shown the benefit of using structure within intervention strategies for this population (Schopler et al., 1971, Rutter and Bartak, 1973). However, Rutter and Bartak (1973) emphasise that this type of structure does not imply any kind of rigidity, rote learning, discipline or forcing, which are all potential approaches to imposing a high level of structure on an environment. Structure in the case of TEACCH is instead the orientation of the task in such a way that provides guidance to the child in how to make the most of the learning opportunity.

The TEACCH program views autism as a culture due to the fact it manifests in patterns of behaviour that are distinctive and predictable. The Structured Teaching approach incorporates a range of teaching or treatment principles and strategies, and is grounded in the characteristics of the 'Culture of Autism' (Mesibov et al., 2007). The characteristics of this culture cover the differences in thinking, learning and neurobehavioural patterns observed in ASD (Mesibov et al., 2007) and are defined as the following:

- *The Concept of Meaning*: have difficulties constructing meaning from experiences and also seeing the connections between different ideas and events.
- *Focus on Details; Ability to Prioritize the Relevance of Details*: able to observe the finer details of things, particularly visual details, but have problems determining the importance of these details.
- *Distractibility*: can be easily distracted by periphery sensations, particularly when visual, and can also rapidly switch between sensations.
- *Concrete vs. Abstract Thinking*: have problems with figurative or abstract language and a tendency to interpret situations in a concrete manner. This can have an impact on *social skills and emotional empathy* as social relationships and emotions are particularly abstract concepts.
- *Combining or Integrating Ideas*: find it easier to understand individual facts or concepts than putting them together or incorporating them with related information. Again this has an impact on *empathy,* which requires the ability to hold two different ideas (one's own feelings and another person's feelings) simultaneously.
- *Organising and Sequencing*: related to difficulties with integrating ideas, as organisation requires an ability to focus on both the current situation and a predetermined goal. Also able to master individual steps within a sequence, but have problems comprehending the overall meaning and relationship between the steps.
- *Generalization:* have difficulties applying existing skills or behaviours within a new context.
- *Visual vs. Auditory Learning:* exhibit a preference for visual learning.
- *Prompt Dependence:* due to difficulties can become reliant on prompts and cues from adults, which can result in further *difficulties with initiation*.
- *Strong Impulses:* can be extremely determined in pursuing desired objects, experiences or routines.
- *Excessive Anxiety:* can be susceptible to high levels of anxiety because of an unpredictable/overwhelming environment or confusing expectations, this can result in an *attachment to routines* because of the familiarity and preference for repetition.

Mesibov et al. (2007) state that "Structured Teaching is an eclectic approach that incorporates several important psychological theories and traditions". These theories and traditions along with the characteristics described above inform the six elements of the approach:

1. *Organisation of the Physical Environment* – in a similar way to the Montessori approach with TD children (AMS, 2011) structure is created through the organisation of the physical environment to ensure settings are made as clear, interesting and manageable as possible. This organisation can differ depending on the individual sensitivities and preferences.
2. *Predictable Sequence of Activities* – based on the emphasis on the individual's expectations and meaningfulness of the situation over contingencies (such as rewards and punishments) from cognitive-social learning theory (Bandura and Walters, 1963). A predictable sequence of activities is used to foster an understanding of the environment and also reduce any anxiety issues due to uncertainty or surprise. A number of research studies suggest individuals with ASD have a strength in processing visual information (Grandin, 1995, Hermelin and O'Connor, Quill, 1997, Hermelin and O'Connor, 1970), therefore this sequence of activities should also be introduced in a visual way.
3. *Visual Schedules* – again due to this visual processing strength a visual schedule is displayed at all times to help facilitate transitions and encourage independence by reducing the need to provide additional prompts. This also helps to support the difficulties with organisation due to executive functioning deficits (Ozonoff et al., 1991), as well as with switching focus and engagement issues (Courchesne, 1989).
4. *Routines and Flexibility* – similarly due to issues engaging and disengaging individuals with ASD from tasks (Courchesne, 1989) an appropriate routine is provided to counteract the potential of individuals developing their own inappropriate routines. This also helps with the understanding of environment and development of skills, as well as reducing agitation. It is important this routine has a predictable structure but is flexible in terms of activity details so the individual will focus on the high level structure rather than the finer details, as predicted in WCC theory (Happé and Frith, 2006).
5. *Structured Work/Activity Systems* – because of difficulties with organisation (Ozonoff et al., 1991), visual processing preferences (Grandin, 1995, Hermelin and O'Connor, Quill, 1997, Hermelin and O'Connor, 1970) and engagement difficulties (Courchesne, 1989), visual organisational systems are used to communicate what the individual should do (e.g. written instructions). They are also used to communicate how much work is required (e.g. show number of tasks), how they know they are progressing (e.g. checking off tasks) and what happens after completion (e.g. written explanation). This should enable them to understand, keep focused and undertake the tasks independently.
6. *Visually Structured Activities* – to utilize visual perceptual strengths (Grandin, 1995, Quill, 1997, Hermelin and O'Connor, 1970) three aspects of visual information are incorporated including *visual instructions* (e.g. written directions), *visual organisation* (e.g. well-ordered materials, structure complex tasks visually), and *visual clarity* (e.g. highlight important task components, limit materials, only show relevant information for task).

Technology-based educational interventions could also be designed to adhere to the principles of Structured Teaching, as the technology could provide an organised predictable visual environment and can present the activities in a visually appealing way (Konstantinidis et al., 2009). Therefore the use of well-designed technology-based interventions offers the potential to provide the type of structured learning environment for children with ASD that is advocated in the TEACCH approach. Also by reducing the need for individualised adult attention it can offer a viable option when one-to-one adult support is not available, not financially feasible or not preferred.

2.2.2.2 Technological Interventions

Technology-based educative methods are increasingly regarded as playing a key role in the education of children with ASD (Konstantinidis et al., 2009). Educational technology can be used either as an constant assistive tool or used temporarily as an teaching aid (Goldsmith and LeBlanc, 2004). The use of technology in educational interventions for children with ASD, such as computer-aided learning, has been shown to benefit areas such as literacy skills (Tjus et al., 2001, Williams et al., 2002), facial recognition abilities (Tanaka et al., 2010) and social skills (Mitchell et al., 2007, Piper et al., 2006). Pennington (2010) also suggests that computer-aided instruction could be beneficial in other academic areas such as mathematics and science. Children with ASD frequently need one-to-one adult instruction, but even when this is available there can still be issues with learning due to "non-compliance, lack of motivation, behavioural difficulties and engagement in stereotypical or ritualistic behaviours" (Williams et al., 2002). Technology offers an alternative provision of one-to-one instruction, but also the potential to overcome some of these additional issues.

Previous research has shown that children with ASD often exhibit a strong interest and enjoyment interacting with technology as well as a high level of ability in using it (Higgins and Boone, 1996, Goodwin, 2008, Putnam and Chong, 2008). Researchers have cited a number of benefits that technology specifically offers children with ASD:

- The level of the child's social skills does not affect the interaction with the technology as it does with the class teacher (Bölte et al., 2010) and is particularly suitable for certain "domain-specific" learning (Williams et al., 2002).
- Technology can be used to teach and reinforce specific skills in which children with ASD can exhibit difficulties. It could be possible to use technology for a whole range of skills but previous research has mainly concentrated on communication and social skills (Parsons et al., 2000, Rajendran and Mitchell, 2000, Grynszpan, 2008), which are the skills children with ASD typically struggle with, and has been shown to have a positive effect on learning.
- The same software can be used at both school and home, allowing the child to practice any areas they are struggling with outside of school in a learning environment they are used to and helping to provide training in generalisation (Panyan, 1984).
- A computer screen offers a smaller area of focus than a classroom setting, which means the child is less affected by the external environment and increases concentration on the task (Williams et al., 2002).
- Technology offers a safe environment in which the child can make errors and learn from them without any fear of the consequences, giving the child more confidence to try unfamiliar things (Goldsmith and LeBlanc, 2004, Konstantinidis et al., 2009).
- The material can be delivered in a visual way, which is a preferred way of learning for many children with ASD (Williams et al., 2002).
- The software can be designed to provide as much additional one-to-one individualised support as required, the level of which can be varied between children adapting to their specific learning and other needs e.g. visual/hearing sensitivities (Higgins and Boone, 1996, Williams et al., 2002, Goodwin, 2008). This can potentially reduce the amount of one-to-one teaching time the child requires (Panyan, 1984).
- Technology can give the child more control over their learning, allowing them to work at their own pace and also are often appealing to children with ASD, potentially increasing their engagement in the task (Konstantinidis et al., 2009, Bölte et al., 2010).

- Children with ASD do not like change and technology can provide consistency across tasks, as well as being predictable and familiar (Panyan, 1984, Williams et al., 2002, Bölte et al., 2010).
- Learning through technology has been shown to increase motivation and improve behaviour in children with ASD (Williams et al., 2002, Goldsmith and LeBlanc, 2004, Konstantinidis et al., 2009).

Although the use of technology in the education of children with ASD can be beneficial, it is also important to keep in mind the potential issues that the use of technology could present, which include:

- Reducing the interaction time in class and replacing it with interaction with the technology could further isolate children with ASD, reducing their opportunities for social interaction with the teacher and other children (Higgins and Boone, 1996).
- Children with ASD often have obsessive-compulsive behaviours and the technology could become a focus of one of these, particularly if their special interest is related to technology in some way (Williams et al., 2002).
- It can be hard to tailor technology for each individual child effectively and adapt to their changing needs. When designing technology for this specific group it is difficult to generalise, as what works for one child may not always work for another due the vast differences between children on the autistic spectrum.
- Children with ASD find it hard to transfer skills they have learnt in one environment into another, and they might struggle applying skills they have learnt through interaction with the technology into a real world scenario.
- Not all skills are best taught using technology, it should be used to teach or reinforce appropriate skills and not seen as the answer to all problems experienced in the classroom-learning environment.

Overall the use of technology in educational interventions offers great potential for this population, and despite the concerns of some researchers there is mounting evidence that computers can provide a wide range of benefits to children with ASD. It is however important that this technology is employed in appropriate situations and used to complement other successful teaching methods, to ensure the children still have exposure to social learning situations. This technology also needs to be appropriately designed ideally taking into account current theories of autism and structured approaches to learning as well as input from the ASD child population.

It is imperative for technology designers to be aware of the vast individual differences within this population and the difficulty in achieving a universal technological solution to educating these individuals. It is also very challenging for neurotypical adult designers to understand the needs and preferences of children with ASD. Suitable customisation options and the involvement of this user group in the design process offer two potential solutions to these issues and are discussed in the following sections.

2.3 Designing Technology for Children

This section firstly considers the approach to designing technology for children in general, before narrowing the focus to children with ASD. In order to include appropriate customisation options it is necessary to be aware of children's potential needs and preferences. One approach to this is to use existing design principles developed to guide the development of technology for this population. It is important to recognize that, in contrast to adult users, children mainly use technology for either educational or entertainment purposes (Chiasson and Gutwin, 2005, Nielson, 2010). Therefore designers of children's technology need to choose design principles that provide guidance on ensuring the technology is motivating and engaging. Gelderblom and Kotzé (2008) suggest "theoretical knowledge on children's cognitive development can provide valuable input into the formulation of a framework for the design of technology". Therefore the section begins with a consideration of prominent theories of children's cognitive development, which provides grounding for the subsequent discussion of existing design principles for children's technology and their applicability to an ASD population.

2.3.1 Cognitive Development

2.3.1.1 Stages of Child Development

When designing for children it is important to take into account their current stage of development, as this will affect what they are able to understand and do. Piaget is often considered to be one of the 20th century's most influential child development experts (Hourcade, 2008). Piaget and Inhelder (1969) specify four key factors that affect development, which include:

- *Maturation*: the level of maturation limits what children are able to do both physically and cognitively at any given age. There can be even more variation in children with ASD in terms of the rate of maturation, as autism can affect both their physical and cognitive abilities. Therefore they may not be able to work at the same level as TD children of the same chronological age.
- *Experience*: children learn about the world by experiencing it. However, children with disabilities such as ASD often have more limited experiences due their need for additional support in certain areas of everyday life, which could restrict their development in these areas.
- *Social Aspects*: social interaction between generations is an important process for passing on a range of knowledge. Consequently, having a deficit in social skills could again impact the development of children with ASD.
- *Motivation and Emotions*: children need to be motivated to learn, and this can be achieved by linking to their interests and everyday lives. This is particularly important for children with ASD who can be uncooperative in activities that do not interest them (Attwood, 1998).

Piaget (1977) has also defined stages of child development, which describe the key stages in the development of logical, analytical and scientific thinking (see Table 2.1).

Stage	Age Range	Key Characteristics
Sensorimotor	Birth – 18/24 months	- Understand object permanency
Pre-operational	18/24 months – 7 years	- Use symbols and words - Distinguish reality from fantasy - Still egocentric
Concrete Operational	7 years – 11 years	- Classify things - Understand reversibility and conservation - Think logically not abstractly
Formal Operational	11+ years	- Can deal with hypothetical situations - Use deductive reasoning - Able to test out ideas

Table 2.1 – Piaget's Stages of Development

There has been much criticism of these stages as children go through the stages at different speeds that do not correspond with the age spans set out by Piaget and there can be inconsistency in how children behave across different tasks (Hourcade, 2008). Also some children, particularly those with cognitive disabilities such as ASD, may not ever reach the later stages of development in relation to certain characteristics. However, Hourcade (2008) states these stages can still be useful in identifying why children may have particular issues interacting with technology.

2.3.1.2 Zone of Proximal Development

Vygotsky (1978) took a socio-cultural approach to learning and development, proposing the "zone of proximal development" which is the distance between what the child is able to achieve on his or her own, and what he or she is able to achieve under the guidance of an adult (or more-able peer). This is also referred to as "scaffolding". Hourcade (2008) suggests that technology could also potentially provide this scaffolding. This approach shares similarities with the Structured Teaching approach developed by Mesibov et al. (2007), where the adult 'scaffolds' the environment and sequence of activities to provide the best possible opportunity for the child with ASD to learn successfully. This supports the possibility of integrating technology with Structured Teaching to provide a suitable learning environment for children with ASD.

2.3.2 Design Principles

Design principles help to inform the design of the technology user experience at a high-level, suggesting what should be included and avoided within the interface design, but not specifying specific features (Rogers et al., 2011). They also provide a cost-effective approach to designing technology for specific populations where time and resources may be limited (Gelderblom and Kotzé, 2008). Many of the basic design principles for adults also apply to children (Hourcade, 2008), but assumptions are often made that users of adult technology are able to read, type and comprehend certain concepts (Large and Beheshti, 2005). Therefore it is important that the additional needs and preferences of children are also taken into account within any set of principles aimed at designers of children's technology.

Some researchers have proposed design principles that attempt to generalise the abilities, interests and needs within the child population, and in certain cases could apply to a range of different technology platforms (Chiasson and Gutwin, 2005, Large and Beheshti, 2005, Hourcade, 2008, Nielson, 2010). Although many of these principles will also apply to children with ASD, they can have additional needs as well as specific sensitivities and preferences within certain aspects of the design. Below is a summary of general design principles for children's technology along with further discussion about applicability to children with ASD (in italics) where relevant.

2.3.2.1 Visual Design

1.1. Children like animation and sound (Nielson, 2010), but do not want unnecessary graphics and animations, particularly as excessive use of these elements can be distracting and have a tendency to narrow the age range that the interface appeals to (Large and Beheshti, 2005, Nielson, 2005).
   - *The use of certain sounds can trigger anxiety in some children with ASD who have auditory sensitivities and so should be used with caution (Putnam and Chong, 2008, Davis et al., 2010, Leach, 2010), ensuring there is an option to turn sound off.*

1.2. Colour can be used enhance children's interaction experiences (ETSI, 2005), but children can express preferences for colour combinations that go against recognized guidelines for colour use within interfaces (Large and Beheshti, 2005). Therefore it is important to strike the correct balance between creating both a clear and appealing design.

- *Colour schemes should be kept simple for children with ASD, with the option to change colours, for example the background colour to reduce contrast with text and aid reading (Leach, 2010).*

1.3. Real-life content specific graphical metaphors are appropriate for children, particularly as a way to minimise text for those with reading difficulties. However, more abstract metaphor representations should be used with caution, and designers should bear in mind their relation to age and culture, sticking to existing stereotypes and standards where possible (Chiasson and Gutwin, 2005, ETSI, 2005, Nielson, 2010).

- *Children with ASD can have problems understanding abstract concepts; so abstract metaphors should be avoided (Mesibov et al., 2007), graphical representations should be as realistic as possible (Leach, 2010) and photographs are preferential to drawings (Higgins and Boone, 1996).*

1.4. Icons should represent actions or objects in a meaningful and uncomplicated way to ensure children intuitively understand what they represent and how they can interact with them (Hanna et al., 1998, ETSI, 2005, Hourcade, 2008). Symbols and icons can also be used to help overcome problems with literacy (ETSI, 2005).

- *Symbols can be used as an alternative representation to text (Leach, 2010), although it is important that there are concrete representations due to children with ASD struggling with understanding abstract concepts.*

1.5. Functionality should be indicated through rollover audio, animation and highlighting (Hanna et al., 1998, Chiasson and Gutwin, 2005).

- *Again it is important to consider sensory issues when using animation, sound and highlighting through different colours when designing for children with ASD (Putnam and Chong, 2008, Davis et al., 2010, Leach, 2010), particularly if being used in conjunction with one another as they can struggle to know where to direct their focus (Davis et al., 2010).*

1.6. Text should be minimized, ensuring the font is legible, avoiding abbreviations and potentially offering an option to read aloud or display through different media (Hanna et al., 1998, ETSI, 2005), as there can be a huge variation in reading ability and children can be too impatient to read through textual instructions (Chiasson and Gutwin, 2005, Large and Beheshti, 2005, Hourcade, 2008). There is also evidence that the more experienced child users tend to read less (Nielson, 2010). An appropriate style of language for the targeted age group should be used, and animating text or placing text over pictures avoided to ensure readability (ETSI, 2005).

- *Children with ASD can exhibit even greater difficulties with reading than TD children and so text should be kept to a minimum (Leach, 2010) and their strength for visual processing incorporated within the design wherever possible (Barry and Pitt, 2006, van Rijn and Stappers, 2008b, Davis et al., 2010).*

1.7. Young children can struggle with hierarchies and categories; so all options should be presented on a single level wherever possible (Chiasson and Gutwin, 2005, ETSI, 2005, Hourcade, 2008). It should be ensured that it is as easy as possible to access the main menu, and scrolling and hard to find interface elements minimised wherever possible (ETSI, 2005).

1.8. Content should be age appropriate and not incorporate any inappropriate materials, links or references such as portrayals of violence (ETSI, 2005).

2.3.2.2 Feedback and Guidance

2.1. Tasks should be intuitive or for more complex tasks provided with scaffolding to guide the user through the task and help them remember for future use (Chiasson and Gutwin, 2005), as in general children will not read help documentation (Large and Beheshti, 2005).

- *Children with ASD like environments that are predictable, structured and controlled, they prefer tasks that have a consistent structure with a clear start and finish (Davis et al., 2010, Leach, 2010). More 'open' tasks can cause difficulties when children do not know which option to choose (Grynszpan, 2008). It is also important to structure tasks to discourage inappropriate repetition as this is something children with ASD can become fixated on (Davis et al., 2010).*

2.2. On-screen characters can be helpful in providing guidance or to direct attention (Hanna et al., 1998, Large and Beheshti, 2005).

- *On-screen characters in the form of a computer buddy or avatar can be particularly helpful for children with ASD (Higgins and Boone, 1996), as they frequently can need guidance on where to focus (Davis et al., 2010).*

2.3. Multimodal help should be available to cater for children of different abilities (ETSI, 2005).

- *Multimodal help may not be appropriate for children with ASD as they can become overwhelmed by multiple multimedia outputs due to focus and processing difficulties (Grynszpan, 2008, Davis et al., 2010).*

2.4. There should be some mechanism to reverse actions, as children prefer to explore in a non-systematic way, using trial and error, and therefore this will help to encourage exploration (Chiasson and Gutwin, 2005, Hourcade, 2008). It is also important to bear in mind that once children have found a successful interaction method they will tend to reuse the same method even if it is not the most efficient (Nielson, 2010).

- *Children with ASD are different to TD children with respect to the typical way they explore. Children with ASD are very systematic (Baron-Cohen, 2009) and so prefer a highly structured environment to explore (van Rijn and Stappers, 2008b, Davis et al., 2010, Leach, 2010). It is also important that children with ASD are not penalised for reusing a method that has previously been successful, as they can find failure very debilitating (Davis et al., 2010).*

2.5. Actions should have a direct effect on the interface and feedback should be given quickly. Otherwise children can become impatient or confused as to why there has been no immediate reaction to their input, potentially repeating the same action multiple times (Chiasson and Gutwin, 2005, Hourcade, 2008).

- *Giving direct feedback on actions will help children with ASD to feel in control (van Rijn and Stappers, 2008b). Although it should not distract from the task (Leach, 2010) and feedback on any failures should be non-critical and provide alternative strategies for achieving success with the next attempt (Davis et al., 2010).*

2.3.2.3 Motivation and Engagement

3.1. The use of on-screen agents, embedded fun features and the design of novel tasks can help increase children's engagement (Hanna et al., 1998, Chiasson and Gutwin, 2005), which is important as they can typically have short attention spans (Nielson, 2010).

- *A survey of parents and carers of children with ASD also highlighted the importance of 'fun' within software and technology (Putnam and Chong, 2008).*

3.2. The use of reward structures can help keep children engaged and extrinsic rewards such as multimedia messages, scoring systems and bonus activities can be very motivating for children (Chiasson and Gutwin, 2005). When progressing to more complex tasks it is important that children still have regular opportunities to be rewarded to ensure their motivation is sustained (Hanna et al., 1998, Chiasson and Gutwin, 2005).
   - *Children with ASD enjoy sensory rewards and can be very motivated by rewards related to their special interests. However, it is important the reward is not over-stimulating and to bear in mind the incorporation can both help and hinder if the reward distracts too much from the task (van Rijn and Stappers, 2008b, Leach, 2010).*

3.3. Personalisation is important, particularly as children's preferences for colour, layout, icons and animations can differ greatly. Enabling certain interface elements to be customised can help the design be appealing to wider age groups and across genders (Large and Beheshti, 2005).
   - *The vast variation in abilities, needs and preferences means that personalisation is particularly important for children with ASD (Farr, 2010). Users should be allowed to set colour and sound preferences to match their sensory issues and also incorporate materials related to their special interests where appropriate (Putnam and Chong, 2008, Leach, 2010).*

These principles are by no means an exhaustive list, but help to highlight the key areas that are important to consider when designing technology to ensure it is both appropriate and appealing to children. Although there are many overlapping principles, with some ASD-specific principles also applicable to a subset of TD children, it is important to recognise the areas where different needs and preferences apply when designing for children with ASD. Barry and Pitt (2006) emphasize the need to incorporate their strengths and support their special needs when designing software for an ASD population, mirroring the beliefs of the TEACCH program (Mesibov et al., 2007) within an interaction design context.

Due to the wide variety of abilities, interests and specific needs across the child population as well as the constantly evolving nature of technology, distinct differences between narrow age groups and level of computer literacy, it is very difficult to develop a set of technology design principles for children that is applicable long term. Gelderblom and Kotzé (2008) admit that "no set of guidelines alone will guarantee design success" and it can be very difficult to determine the extent to which following a set of design principles impacts the success of the resultant technology.

While design principles provide technology designers with a good starting point there are still issues with simply using a generalised set of principles when designing for such a diverse population, whose needs, preferences and technical abilities are evolving as rapidly as the technology itself. It is also important to bear in mind that "development is frequently complex to assess in individuals with ASD because often they do not follow normal developmental progressions" (Mesibov et al., 2007). Therefore it is valuable to involve the children themselves within the design process, as they are the 'experts' in what their needs, preferences and abilities actually are. This is particularly true in the case of children with ASD as it is very difficult to predict what their needs and preferences will be at any given developmental stage. The potential of children with ASD to participate within the design process and specific methods for enabling this participation will be discussed in the following section.

2.4 Designing Technology with Children

2.4.1 Concept of Participation

This section considers what it means 'to participate'. Participation has been defined as both a general (Wulz, 1986) and multi-dimensional (Kirby et al., 2003, Sinclair, 2004) concept. It can encompass the level, nature, frequency and duration of the participation, the focus and content of the decision-making and the groups of people involved in the process (Kirby et al., 2003) There are numerous published definitions of participation covering very different processes (Kirby et al., 2003), but generally they all acknowledge that participation encompasses different sets of interests and involves sharing some element of the decision-making affecting one's life or the life of the community in which one lives (Hart, 1992). It can also be referred to as democracy, involvement, sharing or co-operation (Mumford, 1983). The key point here is the action of decision-making, i.e. being given the opportunity to have an influence rather than simply providing an opinion on it. Participation should be seen as a collaborative process, but it can be viewed differently by each individual or group involved in the process, as potentially they can have distinctly different objectives for what they want to achieve from their participation. The participation process needs to have some clear benefits for each of the stakeholder groups involved to achieve a successful and balanced output. Hart (1992) states that participation is "a fundamental right of citizenship" and since the establishment of the UN Convention on the Rights of the Child (UNCRC) (UNICEF, 2008) this right has been extended to also include children.

The UNCRC is seen as one of the key developments in the field of child participation. It is a fixed set of standards and obligations agreed upon by world leaders in 1989, and part of which gives all children the right to participate fully in family, cultural and social life. Article 12 within the UNCRC states that children have the right to be consulted on all issues that affect them, and additionally Article 13 states that children should be able to express their views and ideas through the media of their choice (UNICEF, 2008). Therefore children should be seen as active citizens within society who are 'experts' in their own lives (Council of Europe, 2004), and provided with appropriate opportunities to allow them to contribute to decisions that impact them. In addition to having the *right* to participate there are other motivations for giving children the opportunity to participate. Including children within relevant participation processes can provide benefits for the service/product outputs of these processes and also can have personal and social developmental benefits for the child participants themselves (Kirby et al., 2003).

Researchers have proposed a number of benefits that can result from participation. These include boosting self esteem, giving a sense of empowerment, providing opportunities for peer learning and potentially improving future job prospects as well as teamwork, conflict resolution, decision-making, communication and prioritisation skills (Kirby, 1999, Council for Europe, 2004, Sinclair, 2004, Malone and Hartung, 2010). Participation is as much about the skills gained and knowledge learned by the participant during the process as the difference that their actions and decisions make to theirs and others lives (Percy-Smith and Thomas, 2010). However, these types of long-term benefits are typically very difficult to measure empirically (Hart, 1992), particularly due to the varied cognitive and social development of children that naturally takes place over time.

Participants can have varying degrees of involvement within a project, but in order to participate fully they should ideally be viewed as experts in their particular field and empowered to make all of the decisions about aspects of the project that will directly affect them. Participation within a project can either be offered by the facilitators of the project or demanded by potential participants that may be impacted by the project.

Children should not be forced to participate in the same way as adults, but their participation should be more flexible and tailored to the individual needs of the children involved, wherever possible. These needs will differ over time as the child develops and their level of understanding regarding the outcomes of their decision-making increases. This level of understanding is not necessarily linked to age (Percy-Smith and Thomas, 2010) as children mature at different rates. It is important to take into account that childhood is a time-limited period of an individuals' life, but some children with certain developmental disorders may not reach full maturity as TD children would during this time. Sinclair (2004) also suggests that participation incorporates the following elements:

- The level of active engagement the child has in the process.
- The focus of the decisions the child is contributing to, for example whether they are public or private decisions or if they will affect the child as an individual or as part of a larger group.
- The form of participation, whether it be as a one-off project or an on-going partnership.
- The appropriate form of dialogue and engagement to correspond to the child's current age and ability.

These are all points that need to be considered and defined in advance of any participation process involving children. Hart (1992) also states that a number of requirements should be met in order for a project to be called *participatory*, which include children having understood the intentions of the project and the reasons for their involvement, being allowed the opportunity to undertake a meaningful role and to choose whether to take part or not once they have understood what the project entails. If these requirements are not met then the involvement of the child could be viewed as a form of exploitation.

The form of participation within a project is often defined in terms of the adult-child interaction within the project and how they share power (Kirby et al., 2003). These forms range from the child having an awareness of the project, but having no power to influence decision-making in any way, through to having, or at least sharing, the power to make the final decision in different aspects of the project. Recently researchers have raised the question of what is considered enough engagement within a project to be defined as participation and how forms of participation can be interpreted differently across domains (Vines et al., 2012).

There are a number of models, which attempt to define the different forms of participation. One of the most prominent models depicts these forms as a 'ladder', and suggests in addition to genuine participation there are also three forms of non-participation, where the children are involved in the project but not in a meaningful way. 'The Ladder of Participation' (see Fig. 2.1) was originally proposed by Hart (1992), adapted from Arnstein's 'Eight rungs on the ladder of citizen participation' (Arnstein, 1969), and has since been extremely influential in the field of child participation despite being frequently criticised by other researchers in the field. Their main criticism is that the ladder suggests a hierarchy in which the ultimate goal of a participatory project is to achieve the top rung of 'Child-initiated, shared decisions with adults'. The most appropriate form of participation may vary depending on the nature of the project and the child's individual abilities, characteristics and additional needs. The three alternative models of participation presented below have attempted to address this critique.

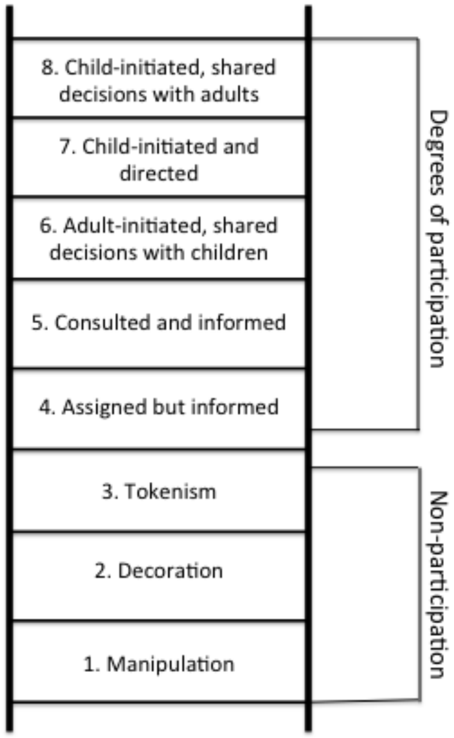


Figure 2.1 – Ladder of Participation (adapted from (Hart, 1992))

As an alternative to this hierarchical layout Treseder (1997) has developed a model of participation, which takes the participation rungs of the ladder and places them within a spider diagram including a further description of each approach, and removing the hierarchical layout from the model (see Fig. 2.2). However, it essentially defines the same forms of participation as Hart's model. Shier (2001) has also defined a model (see Fig. 2.3), which includes different degrees of participation in terms of openings, opportunities and obligations by considering both the potential and realistic expectations of power sharing between the participants (Kirby et al., 2003). The difference here is the lowest forms of participation are about listening to and supporting the children rather than simply informing them of what is going on or involving them in a tokenistic way, so they have a greater level of involvement even at the lowest level. Kirby et al. (2003) using Article 12 as a starting point, have similarly excluded any tokenistic or manipulative approaches from their model and focused only on those forms where children are able to actually influence the project (see Fig. 2.4). These models help to highlight the different levels of empowerment that can be granted to children within a participatory project (Kirby et al., 2003), and the appropriate level can depend on the needs/ability of the individual participants and the context of their participation.

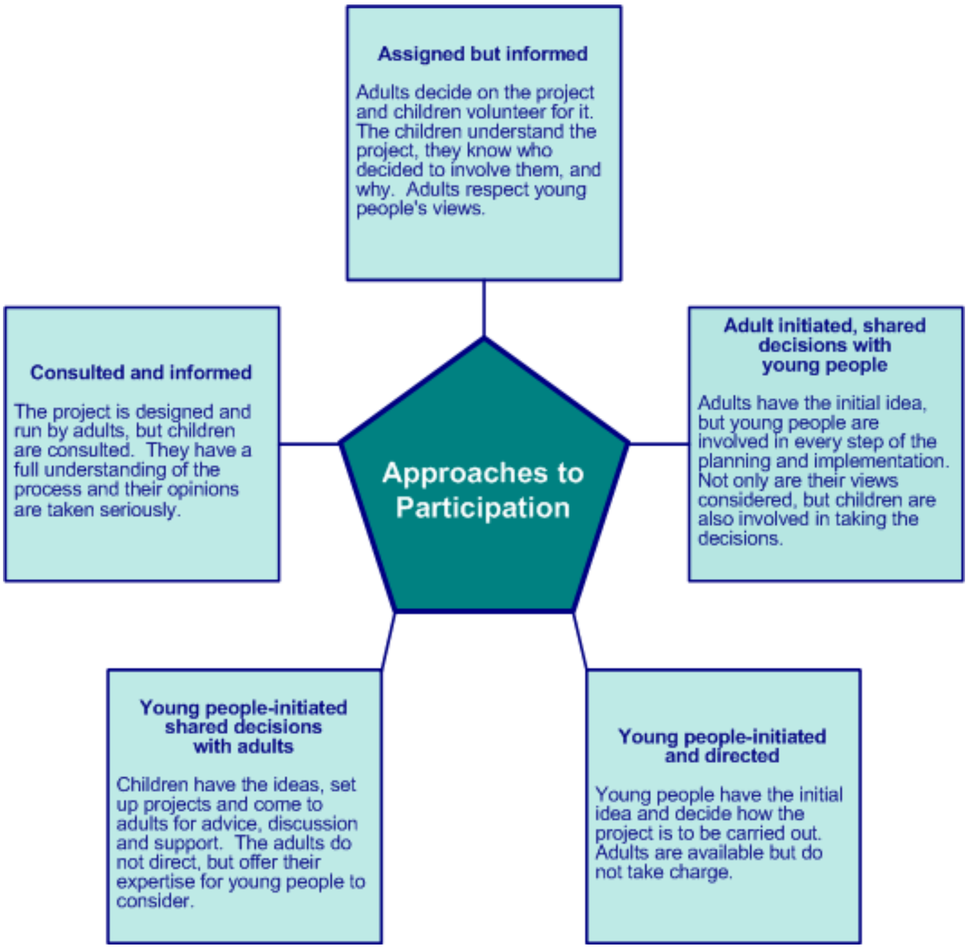


Figure 2.2 – Approaches to Participation model (Treseder, 1997)

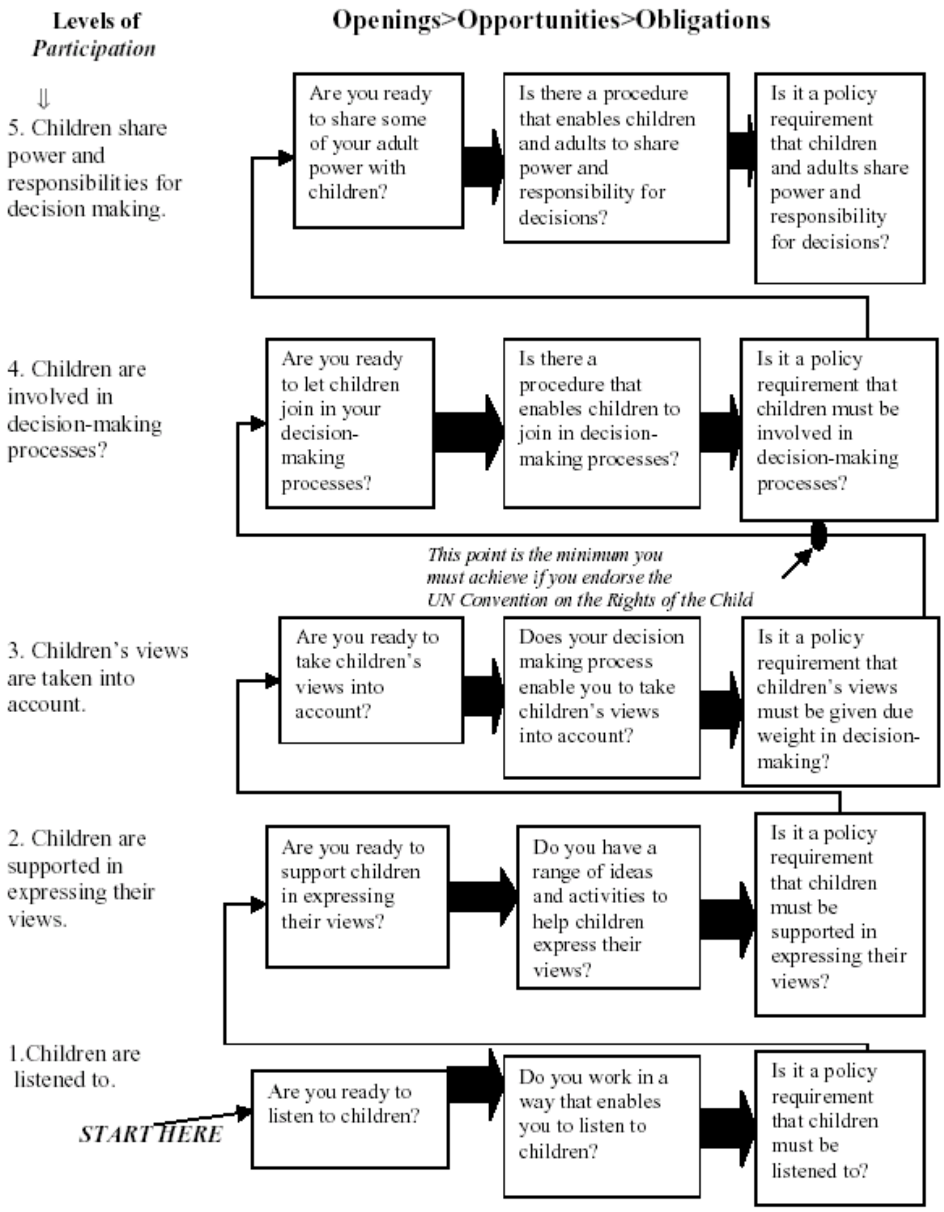


Figure 2.3 – Pathways to Participation model (Shier, 2001)

Figure 2.4 – Level of Participation model (Kirby et al., 2003)

Allowing children to undertake different levels of participation is particularly pertinent in the case of disabled children, who may not be able to participate in the most demanding roles but who should still be afforded equal status and validity at whatever degree of participation they are able to manage (Franklin and Sloper, 2009). It is important not to overwhelm them with too much control if they are not able to cope with it, but at the same time provide sufficient opportunities and support for them to develop the skills and knowledge to participate as fully as possible within the process.

2.4.1.1 Establishing a Culture of Participation

Although there has been considerable progress made in the provision of opportunities for children *to participate*, the next step is to transition from *one-off* projects to developing a *culture* of child participation. There are still a number of barriers to children's participation and there is also evidence that for children with disabilities this progress has been slower (Franklin and Sloper, 2009). One key issue is that the UNCRC is still more concerned with the protection of children (Hart, 1992) and children's participation rights are often in conflict with their provision and protection rights (Alderson and Montgomery, 1996). This conflict directly relates to the power balance between adults and children and is one of the main barriers to the successful participation of children.

Whether explicit or implicit, adults typically are seen to hold all the power in society and they can sometimes view children as not yet fully competent or in need of protection. It is important that the adults recognise the value that children can bring as participants and are prepared to relinquish some of their control to empower the children, enabling them to undertake a more substantial role in the participation process. There are also further barriers which McNeish and Newman (2002) summarise as the additional time required to involve children; the extra skills participants need to develop to work together successfully; the added investment in resources required; potential changes needed to existing attitudes and the slowing down of the decision-making process due to additional negotiations between participants.

Social class, gender and disabilities can have further impact on potential inclusion within the participation process, often due to existing prejudices, and in the case of children with certain disabilities their additional needs and support required in respect to communicating their views (Hart, 1992, Franklin and Sloper, 2009). Children who are seen as particularly difficult to reach are those with communication impairments, ASD or complex health needs (Franklin and Sloper, 2009). It is these children who are particularly at risk of exclusion from the participation process and therefore it is important that there is a specific focus on including these groups (Franklin and Sloper, 2009). According to Luck et al. (2001) it is actually more important to involve minority groups such as those with disabilities, as generalised population data is rarely useful in these cases, due to the vast array of individual differences typical of minority populations. Within minority populations such as ASD there are a number of common deficits, however individuals can experience these deficits to different degrees and with different behavioural manifestations. Decisions on what is best for these groups is often based on assumptions, prejudices or stereotypes from people who have little knowledge of the difficulties and needs of specific minority populations (Kranzl-Nagl and Zartler, 2010).

The guidance and regulations laid out in Article 13 of the UNCRC (UNICEF, 2008) state that disabled children should not be assumed to be unable to participate and instead be provided with the appropriate communication aids where necessary. As a result of investigating current good practice in participation, Franklin and Sloper (2009) have compiled a number of implications for policy and practice of the participation of disabled children. These implications include taking a more individualised approach to participation to support children's specific needs. Therefore a 'one size fits all' solution is not appropriate, and any participation process needs to be flexible and have the ability to be tailored to the myriad of needs within minority populations.

There are a variety of approaches to participation and one commonly used approach within the field of technology design is PD, which enables end users to be involved in the decision making process throughout the technology design process. An important reason for the user's participation in technology design sessions is the exploration of their tacit knowledge. Tacit knowledge is implicit, holistic knowledge and is something that people know but are unable to articulate (Spinuzzi, 2005). This tacit knowledge cannot be extracted during a requirements gathering session, but can be discovered through spending significant time with the users and observing them using existing technologies. This process offers additional benefits when those users, such as children with ASD, have communication difficulties and may struggle to effectively verbally explain all of their ideas and opinions.

2.4.2 Involving Children within the Technology Design Process

2.4.2.1 Roles of Children

As stated earlier in this chapter there can be a number of different levels of participation. Several researchers have defined these levels of involvement as 'roles' that children can undertake during the technology design process. The most widely recognised of these are the four levels of involvement proposed by Druin (2002), which include the following:

- *User* - adult researchers observe the children interacting with existing technology. From this the researchers can note which aspects the children like as well as any difficulties they may have.
- *Tester* - the children are observed trialling initial prototypes of the new technology that have been developed and then directly asked for their feedback by the researchers. This is suitable for children that are able to indicate at the very least whether they like or dislike something. This role is also useful to involve larger numbers of children in the design process, without needing the additional resources required for involving them fully in the initial prototype design.
- *Informant* - researchers involve the children at various points during the design when their input is considered of value. This can be through observation of technology interaction, input to prototype designs, or through feedback once the technology has been developed.
- *Design Partner* - the children act as equal stakeholders throughout the entire design process and are consulted at each stage. This role is similar to the Informant role, but crucially the children are considered 'equal partners' and have an equal opportunity to participate at all stages of the design process.

The structure of these levels of involvement could be viewed in a similar way to Hart's ladder of participation and therefore open to the same criticism that the design partner role is seen as the ultimate 'goal'. However, in a recently published paper revisiting these roles Druin and colleagues explicitly state that "This is not to say one [role] is better than the other, only that these roles of informant and design partner are different" (Guha et al., 2012). In addition to these roles, Large et al. (2006) have defined a design method called '*Bonded Design'* which involves children at a level of involvement that falls between the Informant and Design Partner roles in this case. The children are involved as partners throughout the process, but Large et al. do not believe that there can be a true equality between the children and adult participants in the process.

Read et al. (2002) have identified three modes of participation, which range from *Informant Design* where the adult designers make the decisions to realize the design, but children are given the opportunity to inform the designers; *Balanced Design* where there is an equal partnership between the adult and child participants; and *Facilitated Design* where the adults act as facilitators and the children themselves are expected to initiate the ideas and lead the decision making during the design realization.

Kafai (1995) has also involved *children as software designers*, where they are asked to design and build games for their peers either individually or with another child. Here adults provide technical help to the children but the children lead the game implementation. However, the products created in this process are not typically intended for wider distribution and products intended for their own use may differ from what would be designed for use by a wider population.

Hussain (2010) has used both Hart's ladder of participation and Druin's levels of involvement as inspiration for her Design Participation Ladder, which specifically considers the participation of disadvantaged children in developing countries. The ladder includes three levels of participation, *Included* where the adults just observe the children and may ask basic questions of them; *Consulted* where the children are not directly involved in the design but are asked in appropriate ways to establish their requirements and preferences; and *Empowered* where the children have an influence on the design and are given the opportunity to learn skills and participate in developing solutions.

Finally Frauenberger et al. (2012a) have adapted Arnstein's Ladder of Citizen Participation (which Hart's ladder is based upon) to apply to the participation of children with disabilities in the design process. They define three styles of participation which include *Non-participatory* where theories, best practices or previous experiences guide the design process; *Participation via proxy* where a parent, carer or teacher participates on behalf of the child; and *Full participation* where the children are given the opportunity to have a direct impact on the design process. However, this still does not consider exactly what this opportunity provides such as the specific activities the children are involved in.

2.4.2.2 Balance of Power

The balance of power has been raised as a key issue in building a culture of children's participation and each of the roles described above offer different distributions of power between the child and adult participants. Kirby et al. (2003) believe there is a need to redress the traditional power imbalance between children and adults, however this does not mean it can be equally distributed in all situations. Druin (1999) advocates that traditional power structures can be challenged through the use of specially designed activities, having adults wearing informal clothing as well as undertaking the project away from both the classroom environment and the teacher-student authority structure (Taxen et al., 2001). Kam et al. (2006) recognize the need for a departure from the unequal teacher-student power balance and found when they worked with rural school children the adult researchers were able to build up a more equal relationship, but this was disrupted when the teachers were in the same room. Read et al. (2002) also found difficulties overcoming this type of power structure when working within an educational environment. However, this is a reality many researchers are faced by when involving children in PD projects and working effectively within a school-based environment is an important issue to address. Particularly in the case of children with ASD where the teaching staff frequently possess valuable knowledge about how to most effectively work with individual children.

Within the research community there are many reservations about the possibility of achieving a true equal partnership between adults and children (Scaife et al., 1997, Scaife and Rogers, 1999, Nesset and Large, 2004, Vines et al., 2012). Some researchers believe that children do not possess the necessary resources such as time, money, emotional capacity, appropriate cognitive development, knowledge or expertise to have greater or equal power and also that adult designers are unable to view children as peers (Scaife et al., 1997, Hussain, 2010). Hussain (2010) suggests that "empowering children is not about giving them the same role and responsibilities as adults in design projects", but rather developing the confidence to share ideas and opinions with others, acquiring new skills in decision-making, problem-solving, leadership and design methods as well as participating in the development of useful products for both themselves and their peers. Additionally, in a retrospective evaluation of his ladder of participation Hart (2008) proposes that it may not always be appropriate to aim for the 'highest' rungs of the ladder, but instead children be allowed the opportunity of greater participation if they possess the necessary "competence and confidence" to undertake a more involved role. Hart also states that the UNCRC participation rights for children are often misinterpreted to mean that children should always have the "last word", but that they also acknowledge the need for children to comprehend and respect the rights of others.

The roles of children in the technology design process as well as the forms of participation defined in the wider participation literature (discussed in the previous section) are summarized in Table 2.2 in terms of the influence the children can have when undertaking each role. The *Bonded Design* role has also been place at two different levels because although children are treated as partners within this approach, it is not believed that there can ever be a true equality of power.

FORMS/LEVELS OF PARTICIPATION MODELS	**BALANCE OF PARTICIPATION**			
	Children lead, adults have limited influence	*Children and adults share power*	*Adults lead, children have some influence*	*Children have no power*
Ladder of Participation (Hart, 1992)	Child initiated and directed.	Child or Adult-initiated, shared decisions	Consulted and informed	Assigned but informed
Approaches to Participation (Treseder, 1997)	Young people-initiated and directed	Young people or Adult initiated, shared decisions	Consulted and informed	Assigned but informed
Level of Participation (Kirby, 1999)	Main deciders	Deciding partners	Influencing the decision making	Expressing a view Being informed
Pathways to Participation (Shier, 2001)		Children share power and responsibility for decision-making	Children are involved in decision-making process Children's views are taken into account	Children are supported in expressing their views Children are listened to
Level of Participation (Kirby et al., 2003)	Children and young people make autonomous decisions	Children and young people share power and responsibility for decision making	Children and young people are involved in the decision making Children and young people's views are taken into account	
Roles for TD children within technology design process				
(Kafai, 1995)	Children as Designers (adults as facilitators)			
(Druin, 2002)		Design Partners	Informant	Users Testers
(Read et al., 2002)	Facilitated Design	Balanced Design	Informant Design	
(Large et al., 2006)		Bonded Design (task-level)	Bonded Design (project-level)	
Roles for children from minority groups within technology design process				
(Hussain, 2010)		Empowered	Consulted	Included
(Frauenberger et al., 2012a)			Full Participation	Participation via proxy Non-participatory

Table 2.2 – Balance of Participation within the different defined Forms/Levels of Participation from the literature

The ability of adults to share or handover power completely is crucial to achieving the more involved levels of participation from many of the models incorporated in Table 2.2. As highlighted above within society there are existing power structures between adults and children that can be very difficult to redefine within a single design project. This is particularly so, as outside of the project the parent-child and teacher-child relationships continue to persist, reinforcing the power of adults over the children. This is especially significant in the case of children with disabilities as adults frequently act on their behalf due to the difficulties they can have expressing their needs and preferences. In the case of projects that are defined as child-initiated and directed, the question is: are the children ever truly in control? Adults frequently still control access to money and resources, and even if children are initiating project ideas they need adults to offer them the opportunity to realise these ideas.

A further question arising is: should this be what we aim for? In order to fulfil children's right to participate as set forth by the UNCRC (UNICEF, 2008) children's views should be taken into account (Shier, 2001), but they are not required to have complete control over the decision making process. The level of involvement and balance of power should depend on the circumstances of the project and the participants. The benefits of involvement could potentially be negated if the project is too ambitious in what it sets out to achieve, resulting in the participants having unrealistic expectations of their involvement. Alternatively there could be problems if too much is expected of the child participants putting them under undue pressure and potentially causing distress. The skills and confidence gained from their participation in addition to their view of the overall participation experience could be considered as more important (Hussain, 2010) and could have the potential to last beyond the project and generalise to other aspects of the children's life, impacting their well-being and self esteem.

Guha et al. (2008) have developed a model for involving children with special needs in the technology design process, using Druin's levels of involvement as a basis. They state that time, access to children and funding must all be considered when deciding which level of involvement the children are able to undertake. Other aspects that will impact the child's level of involvement include the *nature and severity of the disability* and the *availability and intensity of support*. These two aspects are interlinked as if appropriate adult support is available those children with more pronounced disabilities could potentially have a greater level of involvement. In addition to this model researchers could consider varying the child's level of involvement at different stages of the project depending on what the child is able to manage at any given time. They could also consider increasing the child's level of involvement as they gain experience and skills in participating in these types of projects, which is not noted within any of the current models of participation.

These roles help to guide the balance of power in decision-making during the design process, and this power balance can in turn impact the potential benefits of PD.

2.4.2.3 Benefits of PD

Allowing end users greater involvement in the technology design process through the use of PD is thought to offer a number of benefits both to the resultant product and to the participant themselves, which were initially discussed in a more general context earlier in this chapter. These benefits include giving the participants a sense of empowerment and ownership over the system; increasing their motivation for using the system at the end of the process; providing instant feedback that reduces lengthy testing cycles later in the process; providing a range of perspectives on the system increasing the likelihood of the suitability of the final product; participants developing new skills and potentially improving their perceptions of technology. However, as with any participatory project it is very difficult to empirically measure these benefits as it not known if they have occurred as a direct result of participation or due to other reasons related to the external environment. It is also difficult to determine if some of these benefits may only be applicable in the short term or if involvement in the PD process can have lasting long-term benefits.

Benefits to the participants of the process are also referred to as 'user gains' (Bossen et al., 2010, Bossen et al., 2012), and the question of whether this refers to the participants gaining from the improved output of the design process or from the actual participation in the process has recently been raised (Vines et al., 2012). Researchers who are focused on involving children in the design process have also recently highlighted the importance of exploring the impact on children who participate in the technology design process (Guha et al., 2010). They suggest that qualitative approaches are most appropriate for measuring this type of impact, but admit this can be a 'messy' process.

The levels of participation or involvement in the technology design process can have an impact on the potential benefit a child may derive from their participation. For instance if a child undertakes a less involved role where they have a minimal impact on the final technology they are less likely to have feelings of empowerment or have had the opportunity to develop many skills. The specific role played by the child within the technology design process therefore has implications when considering the benefits of participation.

Children have been involved in PD since the late 1990s. Hussain (2010) defines a PD project with children as a collaboration with them within their own environment in order to generate design ideas and provide genuine opportunities for them to influence design decisions. There have been a small number of projects that have attempted to measure the ways in which children have benefited from their participation in the design process. As stated above this is difficult and time consuming to measure and therefore the evidence gathered is often quite limited, informal and subjective. To this end relevant literature related to PD and children has been reviewed and a number of empirically derived benefits to the child participants have been summarized in Table 2.3 on the following page.

One of the main issues is that this evidence has not been collected in a systematic way, making it difficult to compare across projects. Guha et al. (2010) have therefore proposed a number of methods that could be suitable for further investigating any potential benefits in this area, which include case studies, interviews and ethnography. Many of the methods of data collection presented in Table 2.3 are not ideal for measuring the extent of the stated benefits and are not in line with the recommendations of Guha et al. (2010), for instance the use of a questionnaire to measure a child's creativity skills. They are also not ideal for measuring if participating in the PD sessions had a positive impact on the children in the longer-term or if these were only short-term benefits. This highlights the difficulty and 'messiness' of measuring these kinds of impacts. These methods can also often be quite subjective and could be improved by taking a triangulated approach whereby the benefits are measured using several different methods and involve a number of different stakeholder groups such as the children themselves, the participating researchers as well as parents/teachers that are familiar with the children.

Benefit/Gain	Child or Adult Reported?	Method of Data Collection	Reported By
Technical skills	Both	Interviews, Child-created poster, Journals	(Farber et al., 2002, Good and Robertson, 2006, Bossen et al., 2010)
Teamwork/Collaboration skills	Both	Interviews, Child-created poster, Journals, Research Notes	(Druin, 1999, Druin and Fast, 2002, Farber et al., 2002, Good and Robertson, 2006, Garzotto, 2008, Bossen et al., 2012)
Communication/Discussion skills	Adult	Interviews, Journals, Research Notes	(Druin, 1999, Druin and Fast, 2002, Good and Robertson, 2006)
Learning about design process	Both	Journals, Research Notes, Interviews	(Druin, 1999, Farber et al., 2002, Bossen et al., 2010)
Increased independence	Child	Questionnaire	(Yang, 2010)
Increased confidence	Adult	Observations	(McElligott and van Leeuwen, 2004)
Sense of empowerment	Child	Questionnaire	(Yang, 2010)
Creativity skills	Child	Questionnaire	(Yang, 2010)
Improve future job prospects	Both	Interviews	(Parnell et al., 2008, Bossen et al., 2012)
Enjoyment	Child	Questionnaire	(Large et al., 2008, Mazzone et al., 2008)

Table 2.3 – Summary of Benefits to Children involved in PD

2.4.2.4 Design Approaches and Methods

There are a number of established approaches to the involvement of end users within the technology design process, which have more recently been used with children. As a result of this work several design methods have been developed specifically for enabling the involvement of children within the technology design process.

Within this area of research the terminology used to refer to the ways end users are involved in the technology design process is often inconsistent, sometimes even within the same paper or article. Therefore it is important to make clear within this thesis that the following definitions, originally proposed by Sanders et al. (2010), have been applied to the key concepts within this research area (see Table 2.4).

Concept	Definition
Approach	Describes the overall mindset with which the research plan is to be conducted.
Method	A combination of tools, techniques and/or games that are strategically put together to address defined goals within the research plan.
Technique	Describes how the tools are put into action.
Tools	The material components that are used in design activities

Table 2.4 – Definitions of key concepts related to involvement of end users within the technology design process (Sanders et al., 2010)

There are a number of design approaches that specifically consider the needs of the end user within the technology design process and have been successfully used to involve children. The earliest of which is *user-centred design*, where the user is seen as the subject and has minimal influence on the decision-making process (Sanders and Stappers, 2008) through performing set tasks or providing opinions about previously generated concepts. Although the same term can be used to refer to any approach that involves users at various points throughout the design process, it has traditionally referred to the involvement of users after the technology has been designed to ensure the users needs have been met (Rubinstein and Hersh, 1987). This traditional view of user-centred design can incorporate techniques such as user observation to highlight any potential difficulties with use and qualitative surveys to establish the users opinions of the technology (Nesset and Large, 2004).

A related approach is *Learner-centred design*, which follows the same philosophy of user-centred design, but more specifically focuses on the learner (rather than the user) within the context of educational technology design. The concept of learner-centred design, similarly to user-centred design, can be used to refer to a range of approaches from designing with a focus on the learner's needs, to involving the learner at various stages (or sometimes throughout) the design process (Good and Robertson, 2006).

Informant design is a design approach specifically developed with the consideration of involving children directly within the technology design process. It seeks to allow children to have more involvement than traditional user-centred design. It aims to address the difficulty of establishing the equality between children and adults needed within a PD team (discussed further below), by reducing the demands placed on the children and removing the requirement for children to be viewed as equal to adults (Scaife et al., 1997, Scaife and Rogers, 1999). The children are involved at various stages in the technology design process, where it is deemed necessary and appropriate by the adult designers. Informant design can incorporate techniques such as interviews with the children as well as low-tech prototyping where the children are allowed to provide direct input into the technology design.

PD has been prevalent for over 40 years, but recently has also been referred to as co-design, with both terms referencing "the practice of collective creativity within design" (Sanders and Stappers, 2008). PD is a design approach originally pioneered in Scandinavia in late 1960s/early 1970s. It is a means of designing technology by actively involving the potential end users as full participants throughout the design process (Rogers et al., 2011). PD originally evolved from the collaborative work between technology designers and labour unions to enable workers to influence the new computer systems, which were being introduced within their workplaces (Schuler and Namioka, 1993). However, Sanders et al. (2008) state that the philosophy of PD practice today "is focused more on the exploration and identification of presumably positive future opportunities than it is on the identification and amelioration of adverse consequences".

PD is a collaborative process with the designers and end users working together, both contributing their own expertise to the design sessions. The final design should ideally combine the end users' expertise on the technology requirements with the designers' expertise on how to best realise those requirements within a working system; with decisions made democratically and involving all participants (Hussain, 2010). The field of PD is extremely diverse incorporating influences from a range of subject areas including graphic design, software engineering and psychology. Although the approach was originally developed for use with adult employees in the workplace, it has now been adapted into a number of methods that can be used for a variety of scenarios, including designing technology with children.

Schuler and Namioka (1993) state that PD differs to traditional technology design approaches in several ways:

1. The eventual users are in the best place to suggest how to improve their work processes and are considered the real 'experts' in the design processes rather the developers/designers. This is particularly true in the case of users from minority groups, such as children and those with disabilities, as there can be significant cultural gap between the adult designers and these populations (Hussain, 2010).
2. The users perceptions of and feelings towards the technology are regarded as important as what the technology can actually do.
3. The software and technology are viewed as processes in the context of the environment they will be used in, rather than as products in isolation.

There have been numerous methods for allowing children a greater level of involvement within the technology design process (Walsh et al., 2013). Described below are some of the more prominent methods and techniques, which have been successfully used with TD children. They have also been placed within the context of the previously discussed roles and design approaches (see Table 2.5).

<table>
<tr><th>Role</th><th>User</th><th>Tester</th><th>Informant</th><th>< ></th><th>Design Partner</th></tr>
<tr><td rowspan="2">Design Approach</td><td colspan="2">User-Centred Design</td><td>Informant Design</td><td></td><td>PD/
Co-Design</td></tr>
<tr><td colspan="5">Learner-Centred Design</td></tr>
<tr><td>Design Method</td><td colspan="2"></td><td></td><td>Bonded Design
Bluebells</td><td>Cooperative Inquiry (CI)
CARSS</td></tr>
<tr><td>Design Technique</td><td colspan="2">Observation
Interviews
Surveys
System Logs</td><td>Interviews
Low-tech prototyping
Prototype evaluation</td><td>(Bonded Design)
Needs assessment
Evaluation
Discussion
Brainstorming
Prototyping
Consensus building
(Bluebells)
Visual design
Navigation design
Context exploration
Content design</td><td>(CI)
Sticky notes (existing software)
Big ideas (combining ideas)
Bags of stuff (low-tech prototyping)
Mixing ideas (staged idea generation)
Layered elaboration (idea elaboration)
(CARSS)
Requirements gathering
Design
Evaluation of prototypes</td></tr>
</table>

Table 2.5 – Relationship between design approaches, methods and techniques used with children

- **Cooperative Inquiry (CI):** CI (Druin, 1999, Guha et al., 2012) is one of the most well established design methods for children and is often used as a basis for some of the more recently developed design methods. It is grounded in the theories of "cooperative design, participatory design, contextual inquiry, activity theory and situated action" (Druin, 1999). CI involves an *intergenerational* design team, which incorporates a mixture of adults and children, with children undertaking a design partner role. CI is aimed ideally towards children aged 7-10 due to the fact they have reached a stage of development that allows them to be verbal and self-reflective enough to discuss their own ideas and opinions, but are not yet too heavily influenced by any pre-conceived notions about how something is 'supposed to be'. The children within CI are viewed as equal 'design partners', with their ideas and opinions being considered as important as the adult team members. The adult team members wear informal clothing to reduce their appearance of authority and conduct the session outside of a classroom setting to help breakdown the traditional power structures that could make it difficult to achieve this equal partnership. It comprises of a number of different techniques, which include:
    - *Sticky Notes:* the design team use an existing technology and then critique it by writing down likes/dislikes/further design ideas on separate sticky notes. These are then organised into categories by an adult who looks for commonalities between the notes.
    - *Bags of Stuff*: this is based on the cooperative design methods used in Scandinavia, and involves small groups within the design team working together using art supplies to produce a low-tech prototype of what they think the new technology should look like. The use of low-tech materials that the children are already familiar with enables all participants to be fully involved in the design process as no specialist skills are required.
    - *Big Ideas*: each of the small groups present their low-tech prototype to the rest of the team and during these presentations one adult notes down any common, surprising, or popular ideas. The team then discusses these 'big ideas' to decide which ones they want to take forward.
    - *Mixing Ideas*: a technique aimed at young children (aged 4 to 6) developed by Guha et al. (2004). The theoretical underpinning of this technique is Piaget's stages of child development (Piaget, 1977), which states that children between the ages of 2 and 6 are egocentric. This means they tend to be more concerned with their own ideas than those of others and struggle to collaborate with other children for fear their own ideas might be lost. Mixing Ideas is based on CI, taking the ideas and methods of involving children as design partners and adapting them by gradually introducing structured collaboration to the design process. This enables younger children to make more valuable contributions to the design process by providing support for the difficulties they have taking the viewpoint of others at the pre-operational stage of development. The technique consists of three stages: 1) *Generating individual ideas;* 2) *Mixing ideas within small groups;* 3) *Mixing ideas within the big group*. Mixing Ideas allows younger children to play a greater part within the design process by providing the additional structure and adult support that they need to facilitate the generation and communication of their ideas. The staged collaboration and the method of combining each child's ideas, enabling them to physically see how their idea has been included within the overall design helps younger children gradually learn how to work within a design team.
    - *Layered Elaboration*: a technique which takes elements from storyboarding for interactive media, paper prototyping and annotation tools (Walsh et al., 2009). The name Layered Elaboration stems from the medium used to expand on the designs of others by adding layers of transparent materials to

the original design. This allows designs to be modified in a simple way that is also easily reversible. The design sessions follow an iterative process. Mixed teams of adults and children design the initial storyboard using paper prototyping techniques. These designs are then presented to other groups who can add their own ideas/changes by drawing on overhead transparencies and layering them over the top of the original design.

- **CARSS (Context, Activities, Roles, Stakeholders, Skills):** Whilst this is referred to as a learner-centred design framework, it has a method of incorporating a combination of techniques and activities for designing interactive learning environments. It is based on a learner-centred design approach, and the theoretical underpinning of this method is within distributed cognition, where "the learner centred design context can be seen as a cognitive system, with cognitive processes distributed across that system", (Good and Robertson, 2006). It provides guidance and highlights potential issues when involving child learners within the design process. CARSS comprises five key components, which include the *context* in which the design activities take place, the design *activities*, the various *roles* undertaken by design team members, the *stakeholders* connected to the design process and the required *skills* for participating within design sessions. It is based on a rapid prototyping approach and contains three separate phases, which include requirements gathering, design and evaluation of prototypes, with the child learners involved across all phases.

- **Bluebells:** This is a design method that addresses various issues that occur when undertaking PD sessions with children (Kelly et al., 2006). These issues include the diversity of children, unbalanced design activities, the children's idea being poorly presented or the amount of time/effort the design sessions take. Bluebells concentrates specifically on the *informant* and *design partner* roles. It has three different stages, which include: *Before Play* - an adult only activity, where the design team identifies the key requirements for the product. *During Play* - child design partners participate in one or more of the design activities, which are based on childhood games and each focus on a different element of the design including visual, navigation and content design as well as context exploration. *After Play* - an adult only activity where the design team use the outputs from the design sessions to produce initial prototypes. The 'During Play' design activities are based on childhood games to make the design process more fun and relevant to the child participants and each activity focuses on gathering a specific type of information about the design (e.g. contextual, content, navigation and interface design).

- **Bonded Design:** This is a design method, which is based on a mix of existing approaches, including learner-centred design, informant design and CI (Large et al., 2006). In the same way as CI it seeks to include children as partners throughout the technology design process, but it shares the reservations of informant design about the potential of adults and children forming a true equal partnership. This is in part due to the additional responsibilities of the adults to set the initial research agenda and organize the sessions as well as bringing the team to order where necessary (Large et al., 2006), which could be particularly important in the case of children with ASD. The Bonded Design teams typically involve 8-11 participants, comprising a mix of adult design experts and children, who are experts in 'being children'. This method includes a number of design techniques that are used during the design sessions, including a 'needs' assessment, evaluation, discussion, brainstorming, prototyping and consensus building. The goal of the sessions is to produce a low-tech prototype of the technology and this can be accomplished over a relatively short period of time.

- **Comicboarding:** This is a design technique, which involves conducting brainstorming sessions with children using specially created comic strips to engage and aid them with the development of ideas (Moraveji et al., 2007). This method is particularly suited to undertaking design sessions in schools in developing regions where rote learning is used, as these children can often find brainstorming difficult. However, Comicboarding can be employed in any situation where children are struggling to generate their own ideas. It uses three different levels of scaffolding, which include:
  - *Dialogue* (Bounded, constrained): This is the most constrained level, where the children simply fill in the empty dialogue balloons.
  - *Panel* (Bounded, free-form): There are completely empty panels within the middle of the comic story for the children to complete, with pre-filled panels at the beginning and end.
  - *Page* (Unbounded, free-form): The first few panels are pre-filled followed by empty panels for the children to complete the comic story. This is the least constrained level.

  The pre-filled panels are used to set a storyline, characters and theme, which is often based on an existing comic that the children are familiar with. To help the children complete the comic stories, an artist translates the ideas that the children describe onto the comic book pages.

Although none of these methods and techniques have been developed with the needs of children with ASD in mind, that is not to say that it would not be appropriate to use elements of these approaches with an ASD population.

2.5 Summary and Research Questions

This chapter has described the characteristics of autism and introduced a number of the existing associated theories. It has highlighted that although these theories can inform a view of autism, they cannot explain the entirety of the condition and there is a need to recognise the wide range of manifestations of ASD characteristics. This need is recognised within the TEACCH education program, which seeks to adapt the environment to support the difficulties and strengths of individuals with ASD. Many researchers now recognise the potential benefit technology can offer with respect to educational intervention approaches for children with ASD, and there is now a large amount of technology being specifically designed for this population. However, it is important that this technology is employed within appropriate situations.

This chapter has also explored existing cognitive development theories and technology design principles for children. These can be useful as a starting point when designing children's technology, where time and resources are constrained, but researchers should be aware of the limits of this approach and the additional benefits that involving children directly in the design process can provide. The different forms of child participation were discussed and it was identified that the highest levels of participation may not always be appropriate for all situations. Within PD, researchers have defined specific roles children can undertake and also highlighted the balance of power between children and adults, which is particularly pertinent in the case of children with more diverse needs. Lastly this chapter presented a number of existing PD methods and techniques, which have been used successfully with TD children, but have yet to be evaluated for use with an ASD population.

2.5.1 Research Questions

This thesis aims to further explore the involvement of children with ASD within the design of this technology, guided by the following high-level research question introduced in Chapter One: **How can the design contributions, level of participation**

and collaboration of children with ASD be best supported to enable their successful involvement within the technology design process? After reviewing relevant literature within the fields of ASD and children's technology design a number of more specific research questions can be initially defined, which are detailed below.

Firstly in relation to the *design contributions* of children with ASD, the extent to which they can generate their own ideas and express these ideas requires further investigation in considering the known difficulties with communication individuals with ASD can experience. This investigation will help to establish what degree children with ASD are able to participate in typical design tasks and where they require additional support. In cases where children with ASD may be unable to communicate their ideas and preferences there is also little guidance for researchers in terms of design principles based on findings from previous research projects in this area. Therefore the first research question this thesis seeks to answer is:

Can children with ASD successfully generate and communicate *design ideas* and what implications do these ideas have in terms of designing educational technology for children with ASD?

The involvement of TD children within the technology design process is now commonplace and there are many well established methods for enabling their participation throughout the design process. However, *the level of participation* of children with ASD needs to be explored further in order to establish the extent to which existing design methods aimed at TD children could be applied to an ASD population and where specially tailored methods and techniques may be required. Therefore a further research question arises, which is:

To what degree can children with ASD participate in the design of technology and taking account of existing theories of autism, how do *existing design methods* need to be adapted to enable this participation?

Some researchers have now begun to consider the involvement of children with ASD within the technology design process and how design methods and techniques could be adapted to involve them. Thus the next chapter seeks to review the existing work in this specific area, further refining and expanding upon the above research questions in accordance with the outcome of this review.

Chapter 3 Children with ASD and PD

3.1 Overview

The previous chapter reviewed the literature within the fields of ASD (including typical characteristics, theories of autism and intervention strategies) as well as children's technology design and PD methods/techniques used for TD children. The findings from this review have given rise to several research questions

The first half of this chapter seeks to further refine these research questions by examining the previous approaches taken with regard to the involvement of children with ASD within the technology design process. The previous chapter highlighted the deficits individuals with ASD can have in communication and social skills as well as rigid and repetitive behaviours. Deficits in these areas could have implications for their collaboration and creativity skills, which are skills typically needed within PD. Therefore this chapter discusses what these implications may be, highlighting key areas that would require additional support within a tailored PD approach and further building on the set of research questions that this thesis intends to answer.

The second half of this chapter seeks to use the findings from the review of existing literature in the development of a new PD method, IDEAS, aimed specifically at children with ASD. The process followed to develop this new method is described and an initial version of the method presented.

3.2 Involving Children with ASD within the Technology Design Process

Madsen et al (2009) state that the use of design approaches such as PD "is an important part of developing technologies that address the specific needs of underrepresented groups, such as those on the autistic spectrum". Furthermore, Frauenberger et al (2011) believe children with special needs such as ASD are a group that can benefit most from involvement in the technology design process. In addition to this Frauenberger et al. (2012) highlight the gap between the everyday lives and previous experiences of children with ASD and adult designers, making it difficult for the designers to fully appreciate the needs of this population.

Although children with ASD have often been involved as users and testers within the technology design process, there are few examples of them undertaking a more involved role and where this does occur sparse details are provided about the design methods used or developed to enable this involvement (Francis et al, 2009).

3.2.1 Previous Involvement of Children with ASD in the Technology Design Process

There are a number of examples of research projects that have previously involved children with ASD in the design process in various ways. These projects are described below, divided into the applicable balance of participation categories defined in the previous chapter, which included the following: i) Children have no power, ii) Adults lead, children have some influence, iii) Children and adults share power, and iv) Children lead, adults have limited influence.

3.2.1.1 Children have no power

The projects described below have involved children with ASD through a variety of ways, either by observing the children using the technology, using parents, carers or teachers as proxies or by allowing the children to test/evaluate the technology during the later stages of the design process. Ultimately though, the children have no opportunity to directly impact the design decision-making process and it is the adults that are responsible for interpreting their needs and preferences.

Using adults familiar with the children as proxies during the technology design process is quite common, particularly with children with low-functioning autism who have more pronounced difficulties with communication. For instance during the design of smartphones to support communication and social skills for children with severe ASD, De Leo and Leroy (2008) used special education teachers as proxies for the children due to the “communication barriers” that prevented the children themselves being engaged in the design process. They felt that the teachers could undertake two roles within the process both from their role as a teacher and by using their in-depth knowledge of the children’s strengths and limitations.

Parents were used as “co-researchers” in the design of a language learning toy for young children with ASD (van Rijn and Stappers, 2008a). Three young boys with ASD were observed in various settings and their parents were interviewed during the exploration phase of the project. Then during the prototype-testing phase the parents and children played with the toy together and the parents were asked to interpret what their child thought of the toy. Additionally during the development of several pervasive computing technologies that provide support for children with ASD and their caregivers, Kientz et al. (2007) felt that it was difficult to rely on direct input from the children themselves so instead observed the children, and then involved the adult caregivers in the design process through interviews.

Lastly, Hirano et al. (2010) included adult “domain experts” as proxies for children with mild to moderate autism in the design of their visual scheduling system for children with ASD. The children were also observed using the system in the classroom, but the authors, along with the children’s teachers, decided that the “burden of involvement” was too high for the children to be involved directly in the design process. The children in this study were not as severely affected by ASD as the studies mentioned above, but it appears the stress and anxiety that involvement may cause the children was the main barrier in this project.

With a focus on the later stages of the design process, Madsen et al. (2009) involved adolescents with ASD in the design of a facial recognition system, with the adolescents’ main role to identify usability issues. All of the participants were verbal, but sometimes they had difficulties articulating the issues they found. Therefore clinical assistants who knew the adolescents also observed them and were able to identify when the participant was engaged and when they were experiencing difficulties. The researchers then interviewed the participants and their teachers at the end of the process. In this case the participants with ASD had a slightly more involved role, but the important design decisions had been made prior to showing the system to the adolescents. This meant they had limited opportunity to have significant impact on the design and instead were undertaking more of a ‘tester’ role.

3.2.1.2 Adults lead, children have some influence

Recently there have been an increasing number of research projects recognizing the potentially valuable contributions children with ASD can make to the design process and therefore seeking ways to allow this population to undertake a more involved role.

Keay-Bright involved children with low-functioning autism as “key informants” within the ReacTickles project (Keay-Bright, 2007b, Keay-Bright, 2007a, Keay-Bright, 2012b). These children had significant communication difficulties and this meant that although the adults still had to take responsibility for the decision-making, they ensured that the children still had “significant impact” on the design process and the project outcome. The design activities proposed by Druin (1999) such as brainstorming and sketching were instead undertaken by the adults. The children were observed interacting with the prototypes at various stages in the design process, with teachers and parents highlighting and interpreting important behaviours. The researchers were conscious not to involve the children to simply test the prototype, but also provide insight into their interests and motivations. As part of this research Keay-Bright (2007b) developed the Research, Inspire, Listen, Develop model, which was applied at each stage of the project. However, this model is extremely high level, providing little guidance about exactly what it involved at each stage and therefore makes it difficult for other researchers to replicate this approach within other research projects.

Keay-Bright (2012a) has progressed this work further in the development of a series of exploratory technology applications called ReacTickles MAGIC. A group of six 15-year old boys with low-functioning autism and three of their teachers were involved in the design process. The boys were not able to communicate verbally, but were still involved throughout the design process during both a four-day design workshop and then a series of weekly design sessions. Iterative prototypes of the system were shown to them and they were observed interacting with them, with their reactions used to inform the next iteration of the prototype. The researchers also involved four boys with AS, who were more verbally able, to provide their thoughts and ideas on the prototype. Although the children in this study were unable to directly contribute towards the decision making process, their involvement from the early stages of the design process enabled them to have a greater impact on the final system and therefore meant they had a more empowered role with the process.

Researchers involved groups of children with HFA as “informers” in the design of MEDIATE an interactive environment to enable non-verbal children with low-functioning autism to express themselves in an enjoyable way (Pares et al., 2006). In this case groups of children with HFA acted as proxies for their lower-functioning peers who would not be able to express themselves verbally during the design process. The groups gave verbal feedback and useful comments on the different stimuli and interactions, although further details on the sessions and the individual activities they participated in were not provided so it is difficult to establish the extent of their involvement and influence.

Piper et al. (2006) included adolescents with ASD within a similar role in the design of a cooperative tabletop computer game for social skills development. The adolescents were involved from the start through observations and interviews about their current social skills class. They also gave feedback on paper and initial computer prototypes. However, they were not involved in the key decisions such as the choice of technology and the game concept, instead providing input into the refinement of the idea and resulting prototypes.

During the development of a suite of multi-touch tablet applications for improving the social skills of children with ASD, Hourcade et al. (2012) involved 26 children with ASD with a range of ages and abilities as well as their teachers, support staff and parents. At the early stages of the design process two girls with ASD were involved and were able to explore and give feedback on existing applications on the tablet. The results of these sessions informed the researcher's choice of four applications to take forward into the development stage. The researchers involved both children with low and high-functioning autism as well as their TD peers in the evaluation to the later prototypes. The children with HFA were able to provide all of their feedback verbally, whereas the children with low-functioning autism were only able to verbally express if they liked/disliked the prototype. For feedback on specific features the researchers used Yes/No post-it notes and asked the children to point to the one that answered their questions. Children with ASD informed the development of the applications throughout the design process, although these were not always the same children and moreover they were only included when the researchers required their input.

Both TD children and children with ASD have been involved as informants throughout the design and development of ECHOES, a system focused on the exploration and improvement of social interaction and collaboration skills (Frauenberger et al., 2011, Porayska-Pomsta et al., 2011, Frauenberger et al., 2012b). The children were initially involved in the design workshops through a series of PD activities developed specifically for this project to inform the look and feel of the system, although it was mainly the TD children who were involved at this stage of the process. There was a small social skills group including two children with ASD and one child with undiagnosed social and language difficulties that also took part in a subset of the activities, with some of these activities having to be adapted for this group (Frauenberger et al., 2011). Expert practitioners and older children with HFA acted as consultants within some of the design workshops. In the later stages of the design process the researchers supported the involvement of children with ASD by using specially developed technology-based tools. These tools enabled children to express their opinions on the ECHOES prototype through the technology itself and helped make the social communication with the researcher easier and less pressurised (Frauenberger et al., 2012b, Frauenberger et al., 2013).

Grawemeyer et al. (2012) also used technology as a tool to help support the contributions of children with ASD to the design of an embodied pedagogical agent (EPA) as part of the development of an intelligent tutoring system for mathematics. Six males with ASD aged 11-15, along with a teaching assistant, were included in the design process using an approach based on a number of CI techniques. The boys began in two separate teams generating individual ideas for EPAs and combined their ideas together in a staged process. They also participated as a large group in a day long "on the fly" rapid prototyping session, where a simple software tool was used to help the group visualise their ideas. It was found that although the boys were able to generate, express and combine their ideas within small groups they struggled combining these ideas within the larger group. The authors suggest that there is a need to restrict the externalisation space for these ideas, as if it is left too open the children may struggle to cope with the lack of structure. The children undertook a role within this process that was closer to a design partner although the adults had to intervene in the decision-making when the children struggled to achieve a consensus in the larger group and therefore the power was not truly shared between the two parties.

Millen et al. (2011) have developed a new method for involving children with ASD in the design process, which is based on a scenario design method. Although the authors do not elaborate on what they mean by 'scenario design' or refer to any specific existing design methods they have based their method on. The method is focused on ensuring that the externalisation space is more constrained and incorporates a series of structured visual activities to help reduce stress and anxiety about participation as well as using personas to support imagination skills. This method was trialled with three children with HFA to support them in designing a friendship game. The method is set out in sufficient detail that it could employed with this population as part of another project. The authors considered the method to be successful as the children were able to understand the tasks, show good engagement in the process and generate good quality ideas that were appropriate for the design of a game for their peers. They do not however, say how they measured either the engagement or the quality, making it difficult to establish the extent to which this method was truly successful. The children did also struggle with the use of personas and what they represented within the process. This work shows the potential this population have to undertake a more involved role within the technology design process, but it has so far only been undertaken over a single session, with little analysis of the results. Furthermore, the authors do not discuss or suggest support for collaboration between the children involved in the session.

3.2.2 PD for Children with ASD

There are no examples of children with ASD and adults truly sharing power within a technology design project, which is typical of a PD approach. Due to the profound social and communication difficulties as well as other behavioural problems that occur within this group the inclusion of adults to facilitate and manage this behaviour is essential, so it may not be possible to ever truly empower children with ASD to these extents. Keay Bright (2007) believes that one of the key factors for this resistance to involving children with ASD more fully in the design process through PD is due to their social difficulties. PD requires “collaboration and communication in teams and demands highly developed interpersonal skills” (Hecht and Maass, 2008). Therefore having a deficit in both social and communication skills could severely impact the ability of children with ASD to participate within the PD process.

3.2.2.1 Implications of ASD Characteristics for Involvement in PD

Researchers have also highlighted a number of other ASD characteristics that could create barriers to involving this population in the technology design process. These characteristics have been identified within the literature and the resulting implications for involvement in PD then considered and summarized in Table 3.1 on the following page.

As these characteristics may occur to varying extents in different individuals with ASD it is difficult to develop a set approach to PD that would be appropriate for all children with ASD. Therefore Francis et al. (2009) advocate a customized approach to involving individuals with ASD within the technology design process, in terms of the structure and management of the specific design activities. Francis et al. (2009) also consulted a panel of experts in ASD to determine the suitability of typical design techniques for an ASD population. They found that although their involvement would be problematic they believed employing and correctly managing an appropriate design process could help to overcome these problems. Frauenberger et al. (2011) recognize that although it can be demanding to include children with ASD in the design process, the potential benefits of developing a more “useful, usable and desirable” product outweigh the additional demands.

Collaboration, communication and interpersonal skills are not fully developed during childhood. Therefore when involving child participants in PD the difficulties and benefits of team communication and collaboration are something that the children need to learn as part of participating within the PD process (Druin, 1999). This is why involving children as design partners requires a such large investment of time in order to build up these necessary skills (Druin, 1999, Knudtzon et al., 2003). Guha et al. (2012) state that idea elaboration is “the hallmark of a good design team with or without children”, but that it can be difficult for children particularly when elaborating upon adults’ ideas. Idea elaboration requires team members to have both good communication skills to share their ideas with the rest of the team, and good collaboration skills in order to integrate their ideas successfully with those of others and reach consensus on the ideas the team wishes to progress.

ASD Characteristic	**Implications for PD**
Impairments in social skills/mindblindness (Millen et al., 2010b, Frauenberger et al., 2012b)	May cause problems when interacting with other members of the design team, may be very direct and potentially insensitive in their criticism. Also may struggle to consider opinions of others when making design decisions.
Communication difficulties (Francis et al., 2009, Millen et al., 2010b, Frauenberger et al., 2012a)	May have problems participating in discussions, expressing ideas and opinions as well as understanding instructions and alerting adults to any difficulties they are experiencing.
Problems understanding/processing emotions (Francis et al., 2009, Frauenberger et al., 2012b)	May not recognize if other team members are upset, frustrated or bored and be unable to adapt their behaviour accordingly.
Rigidity of thought and attachment to routines (Francis et al., 2009, Millen et al., 2010b, Frauenberger et al., 2011, Frauenberger et al., 2012b)	May have trouble adapting to sessions that disrupt their normal routine and are in unfamiliar environments, potentially resulting in anxiety and distress.
Impairments in motor skills (Francis et al., 2009)	May not be able to undertake certain design activities, such as low-tech prototyping, which require more advanced motor skills.
Motivation issues (Francis et al., 2009, Frauenberger et al., 2012b)	May not be fully engaged in sessions that are unrelated to their own special interests.
Cognitive/learning difficulties (Francis et al., 2009, Millen et al., 2010b)	May have difficulty understanding more complex instructions and activities.
Inability to deal with failure (Francis et al., 2009, Frauenberger et al., 2012b)	May assume that there is a ‘correct answer’ to the activities. Concerns about failing to do the right thing may prevent them from sharing ideas and opinions.
Higher levels of anxiety and stress (Francis et al., 2009, Frauenberger et al., 2011)	May be easily stressed particularly when working with unfamiliar people within an unpredictable situation.
Lack of imagination (Millen et al., 2010b)	May struggle with initiating design ideas, particularly when asked to imagine abstract concepts such as a system that is not yet built.
Focus on details (Frauenberger et al., 2012b)	May become fixated on the minor details of the design and fail to consider the ‘bigger picture’ and how everything is linked together.

Table 3.1 – ASD characteristics and their implications for PD

3.2.2.2 Implications of ASD Characteristics on Collaboration

Deficits in both communication skills and social skills due to mind-blindness or below average emphasizing skills are defining characteristics of ASD (Baron-Cohen, 2000b, Baron-Cohen, 2009). These are also the skills that are key to successful collaboration. Communication skills encompass a number of different elements including language, gestures and facial expressions. Although over 50% of individuals with ASD do develop some form of meaningful language there are a number of factors, which interfere with the development of language resulting in lifelong difficulties in this area (Mesibov et al., 2007). These factors include difficulties with understanding the purpose of communication, initiating actions as well as under-responsiveness or over-sensitivity (Mesibov et al., 2007).

Children with HFA/AS have intact communication skills, although it is delayed in those diagnosed with HFA, and therefore are affected by these factors to a lesser extent. However, they have issues with other aspects of communication, which include "unusual prosody, limited understanding of more abstract aspects of language such as humour, sarcasm, and figures of speech, and difficulty carrying on a reciprocal conversation with another person" (Mesibov et al., 2007). There are additional problems with some aspects of written language that includes abstract concepts, resulting in a tendency to interpret both spoken dialogue and written language in a very literal manner. Specific conversation-based difficulties that individuals with ASD can exhibit include selecting appropriate topics of conversation, turn taking and maintaining engagement in the chosen topic. Due to this multitude of difficulties with verbal communication, Mesibov et al. (2007) suggest the incorporation of a visual component can make communication more meaningful for individuals with ASD. Mesibov et al. (2007) also highlight pragmatics as the "most universally disordered aspect of autistic language", which is impacted by further deficits in social skills.

Individuals with ASD across the autism spectrum experience challenges in building and maintaining interpersonal relationships. These characteristic difficulties with social skills can be extremely complex due to the wide range of factors affecting individuals' ability in this area including both language and cognitive skills. Wing and Gould (1979) observed a number of different social behaviour patterns, with the most common pattern occurring in higher-functioning individuals. This is referred to as "socially active but odd", where the individuals with ASD actively attempt to socially interact with others, but others may view these interactions as strange or uncomfortable.

There are a number of neuropsychological characteristics that affect the social skills in individuals with ASD including lack of eye contact, difficulty comprehending subtle social rules and behaviours, mind-blindness and egocentrism difficulties, problems with joint attention behaviours, difficulties interpreting body language, lack of social problem-solving ability, lack of empathy, difficulties with initiation and continued engagement in interaction and influencing spontaneity in areas such as exhibiting helpful behaviours (Frith and de Vignemont, 2005, Mesibov et al., 2007, Lombardo and Baron-Cohen, 2010, Wainer et al., 2010, Schreiber, 2011). They can also find it problematic to generalise previously learnt social skills learnt to new contexts. These issues highlight the specific areas that would need to be overcome within a new PD approach in order to successfully involve children with ASD within the technology design process.

Roschelle and Teasley (1995) define collaboration as a "coordinated, synchronous activity that is the result of a continued attempt to construct and maintain a shared conception of a problem" and in the case of PD this problem is the design of a new technology. Successful collaboration amongst children has been found to involve a significant amount of "mutual engagement, joint decision making and discussion", with verbal communication being one of the most important aspects of this collaboration, including turn-taking, narration, questions and conflict resolution (Roschelle and Teasley, 1995). It is hoped that by placing children within a collaborative environment where certain types of interaction would be expected to occur, this would then trigger learning mechanisms, but there is no guarantee this will actually happen (Dillenbourg, 1999). It is clear that the vast range of communication and social difficulties described above would severely impact the ability of children with ASD to participate within a collaborative design environment and the likelihood of these learning mechanisms being triggered would be significantly reduced. However, the provision of appropriate support for these difficulties could potentially improve the opportunity and likelihood of children with ASD being able to successfully participate within a collaborative environment. In order to establish the specific support required firstly the areas of significant collaboration impairment have been identified (see Table 3.2).

Mechanisms for successful collaboration	**ASD characteristic impacting success**
Mutual engagement (Roschelle and Teasley, 1995)	Difficulty maintaining engagement (Mesibov et al., 2007)
Joint attention and decision making (Roschelle and Teasley, 1995, Fleck et al., 2009)	Problems with mindblindness and difficulties with joint attention behaviours. Lack of social problem solving ability. (Mesibov et al., 2007, Wainer et al., 2010, Schreiber, 2011)
Verbal discussion including turn-taking, narration, questions, negotiation and conflict resolution (Roschelle and Teasley, 1995, Pinelle and Gutwin, 2007, Fleck et al., 2009)	Difficulty with reciprocal conversation including turn-taking and staying on topic. Preference for visual over verbal communication. Lack of social problem solving ability (Mesibov et al., 2007, Schreiber, 2011)
Sharing written messages (Pinelle and Gutwin, 2007)	Difficulty understanding written language that includes abstract concepts and also limited development of social behaviours such as sharing (LeBlanc et al., 2003, Mesibov et al., 2007)
Understanding and using gestures (Pinelle and Gutwin, 2007)	Difficulty with joint attention behaviours including eye contact, following gaze and physical gestures (Mesibov et al., 2007, Wainer et al., 2010)
Maintaining basic awareness (Pinelle and Gutwin, 2007, Fleck et al., 2009)	Lack of eye contact, problems maintaining engagement and difficulty with joint attention behaviours (Mesibov et al., 2007, Wainer et al., 2010, Schreiber, 2011)
Interpreting information from objects and other people's bodies (Pinelle and Gutwin, 2007)	Difficulties understanding subtle social rules and behaviours, problems interpreting body language (Mesibov et al., 2007, Schreiber, 2011)
Coordinating resources with others, both verbally and non-verbally (Pinelle and Gutwin, 2007)	Egocentricity and mindblindness difficulties (Frith and de Vignemont, 2005, Mesibov et al., 2007, Lombardo and Baron-Cohen, 2010, Schreiber, 2011)

Table 3.2 – Typical ASD characteristics impacting successful collaboration

Dillenbourg (1999) has proposed a number of ways to increase the likelihood that successful collaborative interactions will occur and these include:

- The setup of the collaborative environment e.g. team composition and design task
- Assigning specific roles to the participants
- Using rules to scaffold interactions

- Incorporating an adult facilitator to guide interactions

As part of the TEACCH approach to improving communication and social skills in individuals with ASD, Mesibov et al. (2007) have also proposed a number of techniques, which would link into each of the four areas proposed above. The collaborative design environment should be predictable, incorporate the individual interests of the children in some way to motivate engagement, the design task needs to be sufficiently interesting and understandable to stimulate communication and be presented in a visually clear and meaningful way. Additionally the collaborative design environment should be highly structured, which can be achieved partly through the assignment of roles and using rules to scaffold interactions. Finally the adult facilitator should ensure that all communication within the team is clear, understandable and meaningful for the children.

Participating as part of a design team within the technology design process could be classified as an activity-based social skills intervention, providing the child participants with a clear motivation for participating and collaborating with the other team members. Activity-based interventions for children with ASD such as LEGO therapy (Legoff and Sherman, 2006, Owens et al., 2008), which assign the children explicit roles and capitalise on the children's preferred interests in order to motivate participation have proven to be successful in developing the children's social skills. This provides further evidence for the assignment of roles to structure collaboration and the incorporation of the children's interests within the design task. Schreiber (2011) also states that for children with ASD "activities built around special interests may be excellent vehicles for promoting teamwork" and highlights the fact that these skills need to be practiced within a predictable environment.

This support structure is now considered in terms of the activity of idea elaboration, which is a key design activity undertaken by design teams (Guha et al., 2012). Many similarities can be drawn between the older children with ASD targeted within this research work and younger TD children, particularly in terms of the egocentricity they can exhibit (Frith and de Vignemont, 2005, Lombardo and Baron-Cohen, 2010). This can severely limit idea elaboration as egocentric children can be concerned about their ideas being lost during the process and not being included within the final idea due to a lack of understanding as to how several ideas can be incorporated together. Farber et al. (2002) also found that adults need to offer more design suggestions when working with younger children due to the difficulties they experience when collaborating with others.

The Mixing Ideas technique (Guha et al., 2004), described in the previous chapter, which supports the involvement of very young children within the technology design process, provides additional support to help them collaborate with other children during the idea generation process. This support consists of structuring the idea generation process by increasing the amount of adult facilitation and undertaking more of the activities within smaller teams. The actual idea generation is staged and collaboration parameters are established so the children are gradually introduced to the idea of collaborating with others and provided with guidance on how they are expected to collaborate. Adults are also on hand to provide one-to-one support where necessary to ensure the children's ideas are appropriately communicated and documented. The Mixing Ideas technique consists of three stages, firstly the children generate ideas individually, then they mix their ideas with others within small teams and finally they come together as a large team to mix those ideas into one "big idea". Guha et al. (2004) found that taking this staged and supported approach to collaboration enabled the children to be more productive and less frustrated during the idea generation process. Idea generation is an early stage within the creative process, and the ability to develop and discard creative ideas is an important aspect of the design of technology.

3.2.2.3 Implications of ASD Characteristics on Creativity

Much of the current literature suggests that many individuals with ASD have difficulties with imagination and creativity (Wing and Gould, 1979, Craig and Baron-Cohen, 1999, APA, 2000). Researchers have emphasized the function of the imagination in the creative process (Flowers and Garbin, 1989, Gaut, 2003), but this does not assume that individuals with a limited imagination cannot be creative. In contrast other researchers have proposed a positive link between autism and creative ability (Fitzgerald, 2004, Glazer, 2009) often seen in subjects centred around the individual's special interests, commonly occurring in more reality-based subjects such as transport, electronics and science (Attwood, 1998). Liu et al (2010) found that children with AS could be more creative in terms of the elaboration and originality of their ideas, but struggled with openness and flexibility due to their intense focus on ideas relating solely to the topic of their special interest.

Craig and Baron-Cohen (1999) have explored the differences between the generation of reality-based creative ideas and imaginative-based creative ideas in children with ASD/AS and a control group of TD children and also children with mild learning difficulties. They found that the children with ASD/AS produced significantly less novel ideas than the control group and they were more likely to be reality-based. Turner (1999) also found that children and adults with ASD experienced problems during a task which required the generation of abstract designs that did not exist within the real world. The participants often repeated the same idea, with one participant commenting that they had one idea "stuck" in their head and were finding it hard to think of different ideas.

Low et al (2009) state that there is evidence suggesting that deficits in two specific executive processes, generativity and planning, could impact imagination in autism. They state that children with ASD may have a reduced ability to generate novel ideas, as well as having difficulties with visuospatial planning. This means when asked to draw their ideas they could struggle with expressing any spontaneous imaginative ideas they may have as they will not have an established drawing procedure they can employ to translate it onto paper. Therefore children with ASD may have greater success in adding imaginative features to a picture than starting something from scratch as the planning demands are reduced. This suggests that incorporating additional structure through the use of templates may increase the children's likelihood of success. Low et al. (2009) also propose that setting a drawing task within a story may make it more contextually meaningful for the children, increasing their chance of success within the task.

A number of difficulties potentially preventing the involvement of children with ASD within the technology design process have been highlighted within this chapter. However, this thesis seeks to push these boundaries and explore the level of participation and empowerment, both in terms of the acquisition of new skills and the development of useful technology products (Hussain, 2010), which it may be possible for this population to undertake within the technology design process.

3.3 Research Questions

In summary, researchers are beginning to involve children with ASD in the design of this technology, but the degree to which they are able to participate has yet to be fully explored. Few researchers have involved children with ASD from the very early stages of the design process, which underlines the importance of exploring the ability of children with ASD to generate and communicate initial design ideas. This was specified in the first research question set out at the end of the previous chapter:

RQ1) Can children with ASD successfully generate and communicate *design ideas* and what implications do these ideas have in terms of designing educational technology for children with ASD?

In relation to the *level of participation* of children with ASD, there are still many projects opting to use adults as proxies for children with ASD or only involving the children at later stages of the prototype evaluation. This is partly due to the lack of guidelines and design methods available to provide researchers with instructions on how best to involve and provide on-going support for the participation of this population. Keay Bright (2007a) highlights the difficulty of developing a PD approach during the design and development of a new system, but this is frequently what happens as the few projects that do involve children with ASD provide little detail about the process that would enable their approach to be replicated in future projects.

Taking this "on the fly" approach to development means that these design methods are based on observable behaviour rather than incorporating existing theories as a guide. This reduces the likelihood of the method succeeding with a broader range of children with ASD, as outward manifestations of ASD characteristics can vary greatly between individuals on the spectrum. The other issue is that researchers rarely report what does not work and therefore other researchers are at risk of making the same mistakes, which could then become potential barriers to the successful participation of children with ASD. In addition to this few researchers have considered if children with ASD could actually benefit from inclusion in the technology design process. This further highlights a need to explore the second research question set out in the previous chapter:

RQ2) To what degree can children with ASD participate in the design of technology and taking account of existing theories of autism, how do *existing design methods* need to be adapted to enable this participation?

The review of the literature undertaken within this chapter has also given rise to a further research question in relation to the *collaboration* of children with ASD. There is evidence that some research projects are including children with ASD as part of design teams, but their ability to collaborate with the other adult and child team members has merited little discussion. Having impairments in social and communication skills would likely have a major impact on their ability to work within a team environment, however it is not known if these impairments could be overcome if appropriate support is in place. Therefore the third and final research question this thesis seeks to answer is:

RQ3) What factors need to be considered to enable children with ASD to *collaborate* with others during design sessions?

Furthermore, in exploring these questions this thesis intends to provide the following contributions:

i) An understanding of the design contributions children with ASD can make through their involvement in the technology design process.

ii) A set of design principles for designing technology for children with ASD.

iii) A tailored and customisable PD method for enabling children with ASD to participate more fully throughout the technology design process.

iv) An understanding of the ability of children with ASD to collaborate within a PD context.

The next section proceeds to introduce one of these contributions, which is a tailored and customisable PD method for children with ASD.

3.4 Developing a new PD method

The first half of this chapter has highlighted the limited research work that has so far been conducted in the field of PD for children with ASD. The majority of the design methods and techniques used in previous research have been developed "on the fly" for use within a specific project. Often scarce details are provided about the exact methods used, making it difficult for other researchers to employ these methods and techniques in future projects. The development of these methods and techniques is frequently very adhoc and unsystematic, with little consideration given to existing theories of autism. It can also be very difficult to establish the extent to which a method or technique is successful and the reasons behind these successes.

In contrast there are now a number of established design methods and techniques for TD children and these have been published in much greater detail. One of the key aims of this thesis is to develop a PD method specifically for use with children with ASD that can be disseminated in a similar way. Therefore a logical beginning for this research is to analyse these existing PD methods and techniques to determine both the suitability of the current approaches and where the gaps exist, to enable use with an ASD population.

The second half of this chapter begins with the development of a set of criteria for PD methods aimed at children with ASD to fulfil, based on the TEACCH characteristics of the Culture of Autism (Mesibov et al., 2007). Each of these TEACCH characteristics has been applied to a PD context, which has resulted in a set of criteria that should be met for PD methods and techniques to be relevant to an ASD population. Consequently, this set of criteria has then been applied to a number of existing design methods and techniques for TD children to see how well they are satisfied to determine the suitability of each method/technique for use with an ASD population. The results of this analysis is one of the outputs of this thesis and has been used to inform the development of a new PD method, IDEAS, specifically tailored to the needs of children with ASD. The initial version of IDEAS is presented in this chapter.

3.4.1 PD Criteria

The TEACCH characteristics of the Culture of Autism (Mesibov et al., 2007) provide insight into the thinking, learning and behaviours typically seen in individuals with ASD. These characteristics have been developed based on "30 years of observation and close attention to the behaviour and communication of individuals of ASD" (Mesibov et al., 2007). Therefore these characteristics offer an appropriate lens through which to view the potential involvement of children with ASD within the technology design process. It is important to consider how children with ASD will interpret instructions and tasks, their potential for learning how to contribute to the design process successfully, and also how to manage any behavioural issues during the design process.

Each of the TEACCH characteristics (originally introduced in Chapter Two) has systematically been applied to a PD context in order to highlight areas where there may potentially be issues as well as opportunities to increase the likelihood of success of involving this population within the technology design process. This has allowed a set of criteria to emerge that can then be used to analyse the suitability of existing design methods and techniques for use with an ASD population. These criteria are as follows:

- *The Concept of Meaning*: children with ASD may struggle to see the link between their previous experiences with technology and the technology they are being asked to design within a design session.
- *Focus on Details; Ability to Prioritize the Relevance of Details*: children with ASD may put too much focus on the minute details of the task or design and be

unable to prioritise which details are most relevant or see the 'big picture' of the overall technology that is being designed.

- *Distractibility*: children with ASD may be distracted easily, particularly if the design session is held in a noisy or cluttered environment.
- *Concrete vs. Abstract Thinking*: children with ASD may have greater difficulty with the abstract idea of using a paper prototype to represent technology. Furthermore, they may struggle to collaborate with others due to difficulties empathising with other people's thoughts and feelings about different design ideas, which are also abstract concepts.
- *Combining or Integrating Ideas*: children with ASD may struggle to integrate multiple concepts into their design or to combine selected elements from two different ideas into a final design. There are also potential implications for collaborating with others, as in order to compromise on an idea a child needs to be able to hold onto two ideas simultaneously to evaluate the merits of each idea and decide which elements should be taken forward.
- *Organising and Sequencing*: children with ASD may have difficulty achieving a final design without some guidance as to what activities the design session should involve in order to get there.
- *Generalization:* children with ASD may have problems with taking skills or knowledge that they have previously mastered in class and using them during the design session.
- *Visual vs. Auditory Learning:* children with ASD may find it easier to understand things that are presented in a visual way, such as instructions for the tasks during the design session.
- *Prompt Dependence:* children with ASD may have problems initiating ideas without additional prompting.
- *Strong Impulses:* to increase engagement in the design session it may be helpful to incorporate any particularly strong interests in a positive appropriate way.
- *Excessive Anxiety:* children with ASD may become anxious easily, particularly when dealing with new people, so extra steps may need to be taken to put them at ease during the design session, which could include in the incorporation of a consistent or familiar routine.

Although existing established design methods and techniques are primarily aimed at TD children, they could still potentially incorporate features that would be appropriate to use with children with ASD, as there can be overlaps in the needs of these two groups. Therefore the above criteria have been applied to a number of existing design methods and techniques for TD children and the results of this analysis are described below.

3.4.2 Analysis of Existing Design Methods and Techniques

Seven existing design methods and techniques were analysed for suitability for use with an ASD population. The methods and techniques that were chosen were widely used, well documented and had been empirically verified to ensure that they work successfully with TD children. Initially described in the previous chapter, they include:

- The CI method (Druin, 1999)
- Specific techniques within the CI method including Mixing Ideas (Guha et al., 2004) and Layered Elaboration (Walsh et al., 2009)
- The CARSS method (Good and Robertson, 2006)
- The Bluebells method (Kelly et al., 2006)
- The Bonded Design method (Large et al., 2006, Large et al., 2008)
- The Comicboarding technique (Moraveji et al., 2007).

The TEACCH criteria were systematically applied to the published description of each method or technique to establish if it incorporated any particular features that would support each criterion. A summary of the results is described below highlighting existing features that fulfilled the TEACCH criteria (the full analysis can be found in Appendix A):

- *The Concept of Meaning*: A number of existing methods and techniques incorporated the demonstration of existing software to help present the context of the design topic (CI, CARSS, Mixing Ideas, Bonded Design) and it was generally found that this did not negatively impact the creativity of the children's own ideas. The Bluebells method additionally employed a number of childhood game based activities to help gradually introduce the children to the design topic.
- *Focus on Details; Ability to Prioritize the Relevance of Details*: The setup in four of the methods and techniques was sufficient that the adult participants would be able to provide additional support for the children to enable them to focus and prioritise details correctly (Bluebells, CI, CARSS, Mixing Ideas). The Comicboarding technique and Bonded Design method both structured the design tasks in such a way that it directed the children's attention to the correct focus of the task. Bonded Design also used a whiteboard to highlight what had been achieved and what was yet to be achieved in terms of the technology design. This helped to show children the "bigger picture" and understand what is important to focus on next.
- *Distractibility*: Four of the design methods and techniques enabled the sessions to take place in a separate quiet environment with few distractions (CI, CARSS, Comicboarding, Bluebells, Bonded Design). The CI method, CARSS method and Comicboarding technique provided opportunities for customisation of certain elements that could be tailored to the children's interests to help increase engagement. The provision of one-to-one adult support within the Mixing Ideas technique in the early stages of the design process could also encourage children's engagement. The CARSS method gives breaks, intersperses discussion with practical activities or changes the pace of activities to prevent children becoming tired or bored, which could lead to them becoming distracted. Finally Bonded Design incorporates specific activities such as physical activities to help direct the energy of those children that are easily distracted.
- *Concrete vs. Abstract Thinking*: Four design methods and techniques that incorporated the demonstration of existing software provided the children with concrete examples of the technology they were being asked to design (CI, CARSS, Mixing Ideas, Bonded Design). The drawing of paper-based ideas and prototypes was used in several methods and techniques (CARSS, Layered Elaboration, Mixing Ideas, Bluebells, Bonded Design) to help represent the children's ideas in a concrete way. In the later stages of the design process the Bonded Design and CARSS methods also transferred the paper-based designs to a computer-based prototype to provide a more concrete version of the children's ideas.
- *Combining or Integrating Ideas*: A number of design methods and techniques incorporate adult support for combining ideas, particularly where disagreements may occur. This is achieved by the adult undertaking a facilitator role during the process or by providing specific one-to-one support for individual children (CARSS, Bonded Design, Comicboarding, Bluebells). The Layered Elaboration and Mixing Ideas techniques allowed the physical combination of ideas through layered transparencies or the cutting out of paper-based ideas. A staged process to the combining of ideas is also used in Mixing Ideas and Bluebells to gradually introduce children (who may be quite egocentric) to the process of combining their ideas with others. Finally CI uses a sticky note-based activity to enable

children to externalise different ideas and clearly see where there are overlaps with others' ideas.

- *Organising and Sequencing*: A number of ways of structuring the sessions are used to help with the sequencing of activities, these include having clearly defined structured activities and also a staged process to gradually build up to achieving the eventual output of the sessions (CI, Layered Elaboration, Mixing Ideas, CARSS, Bluebells, Comicboarding). The whiteboard used in Bonded Design also provided an overall session map and helped the children to understand the sequence of tasks.
- *Generalization:* The adult facilitation available in a number of the design methods and techniques (CI, Mixing Ideas, Comicboarding, Bluebells, CARSS, Bonded Design) could help the children to generalise existing knowledge and skills learnt by asking questions about previous experiences and making suggestions as to how these experiences could relate to the current design activities.
- *Visual vs. Auditory Learning:* All of the design methods and techniques incorporated visual elements into the majority of the tasks such as the existing software demonstration and drawing activities.
- *Prompt Dependence:* The one-to-one adult facilitation and the highly structured staged process in the Mixing Ideas technique, as well as the highly structured task in the Comicboarding technique may help to support children who struggle with idea initiation due to a reliance on adult input.
- *Strong Impulses:* The CI method, CARSS method and Comicboarding technique offered opportunities to incorporate children's particular special interests. Also Bonded Design incorporated specific activities such journaling and physical activities to help provide children with an alternate outlet for their energy.
- *Excessive Anxiety:* Certain anxieties could potentially be managed through the adult facilitation and one-to-one adult support offered within the CARSS method and Mixing Ideas technique.

The above existing design methods and techniques aimed at TD children provide a range of options for supporting the various ASD characteristics that may negatively impact the involvement of children with ASD in design sessions. The most appropriate and feasible elements have been incorporated within a new PD method specifically tailored to an ASD population. Where existing elements do not sufficiently fulfil the criteria then novel features have been developed and incorporated. This new method has been entitled an Interface Design Experience for the Autism Spectrum (IDEAS) and is described in detail in the following section.

3.4.3 The IDEAS Method

The IDEAS method uses the TEACCH Structured Teaching approach (introduced in Chapter Two) as a framework, which is in turn guided by the previously described characteristics of the Culture of Autism as well as existing psychological theories. More specifically it recognises the characteristics of the Culture of Autism and based on these integrates appropriate supports and strategies to help increase an individual's skills as well as make the environment more understandable for them. Structured Teaching encompasses six key principles, which include the organisation of the physical environment; a predictable sequence of activities; use of visual schedules; incorporation of routines and flexibility; structured work/activity systems; and visually structured activities.

The initial version of the IDEAS method is described below and also presented in diagrammatic form (see Fig. 3.3), organised into each of the principles of Structured Teaching, with the number of the related TEACCH characteristic(s) noted in brackets.

The features inspired by the existing design methods and techniques for TD children are referenced within the description. The novel features are also described below and highlighted in orange within Fig. 3.3.

1. *Organisation of the Physical Environment* – the sessions take place within a quiet and familiar environment (Druin, 1999, Kelly et al., 2006, Large et al., 2006, Moraveji et al., 2007), with one-to-one adult support available at all times (Guha et al., 2004), enabling the tailoring of the environment to individual sensitivities and preferences of the child where necessary.
2. *Predictable Sequence of Activities* – The design activities are explained at the start and presented in a visual way, so the expectations of the session are clear (Large et al., 2006, Large et al., 2008). These activities are also displayed on a visual schedule throughout the session so it is possible to refer back to these whenever necessary (Large et al., 2006, Large et al., 2008).
3. *Visual Schedules* – A visual schedule of the design activities (see Fig. 3.1) is displayed at all times for reference (Large et al., 2006, Large et al., 2008), to reduce the need for adult prompting and to help reinforce the "big picture" preventing too much irrelevant detail focus. As each activity is completed this is checked off by a child participant to help with any difficulties with organising and sequencing.
4. *Routines and Flexibility* – the checking off of design activities on the visual schedule helps provide a familiar routine throughout the session. The one-to-one adult support (Guha et al., 2004) allows the session structure to be flexible and tailored to the child's needs. The use of structured design templates for both the idea generation and interface design activities also allows the adult to provide tailored levels of support if there are any difficulties in these activities (Moraveji et al., 2007).

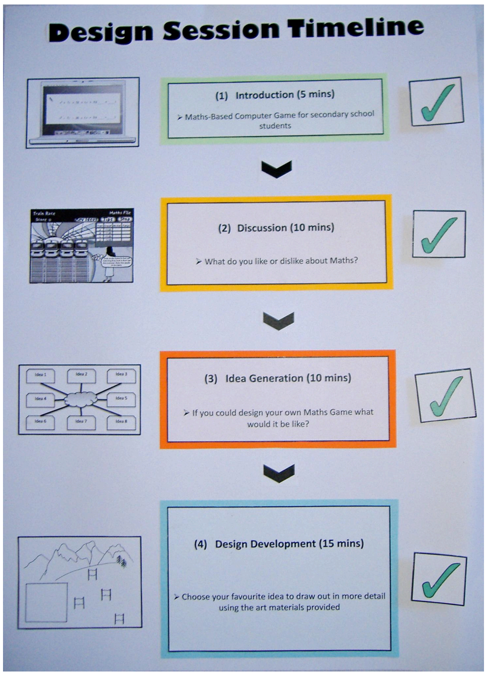


Figure 3.1 - Completed Visual Schedule

5. *Structured Work/Activity Systems* – the visual schedule in conjunction with the verbal explanation from the adult (Large et al., 2006, Large et al., 2008) helps to communicate how each activity should be undertaken in a highly structured way and it also shows how much work is required in order to complete the session.

The checking off of tasks also enables the progression to be easily tracked. The IDEAS method involves four clearly defined activities:

i. An introduction to the session delivered verbally by the adult facilitator, visually supported by the visual schedule.
ii. A discussion of previous experiences related to design topic, and demonstration of existing similar software.
iii. Generation of own ideas within design topic and documentation of ideas on a paper-based template. If the participant exhibits difficulties with this task an adult facilitator can provide an alternative template containing example ideas to help prompt idea generation. The participant then evaluates each idea by giving it a rating out of 10, which is written in the space provided on the template.
iv. One favourite idea is then chosen and the interface design for this idea is drawn out using a limited selection of art materials on a separate paper-based template. Again if the participant experiences difficulty with this task the adult facilitator can provide a part-completed template interface design that the participant can add his or her own additions/modifications to. The finished interface design is then placed inside a cardboard mock-up computer (see Fig. 3.2) and the participant is asked to verbally explain how the user would interact with the interface.

The incorporation of a discussion activity around previous experiences related to the design topic and the demonstration of existing similar technologies (Druin, 1999, Guha et al., 2004, Large et al., 2006, Large et al., 2008) helps to clarify the understanding of the context of the design session. Templates to create structure in the idea generation and interface design activities (Moraveji et al., 2007), as well as the evaluation of the generated ideas provide support for these creative open-ended activities that could be otherwise problematic. Also to increase engagement the sessions should be themed around the typical hobbies and interests of children with ASD.

6. *Visually Structured Activities* – the instructions for the activities are presented visually and all of the activities in the sessions incorporate a visual element (Druin, 1999, Guha et al., 2004, Kelly et al., 2006, Large et al., 2006, Large et al., 2008, Walsh et al., 2009, Moraveji et al., 2007). The more open-ended tasks such as drawing are clearly structured, with a limited amount of art supplies provided to reduce anxiety over choice. Additionally a cardboard computer mock-up is provided to display the paper-based interface design to help provide a concrete representation to support a verbal explanation of the final design.

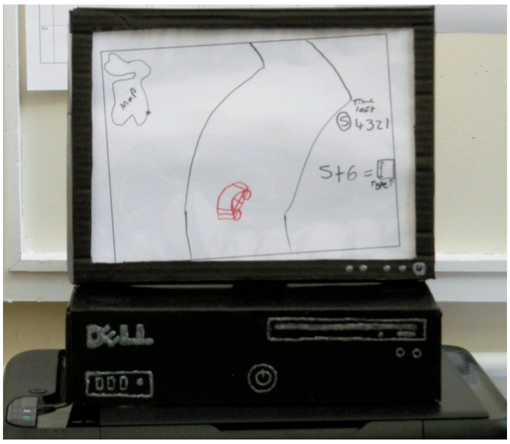


Figure 3.2 – Cardboard computer mock-up

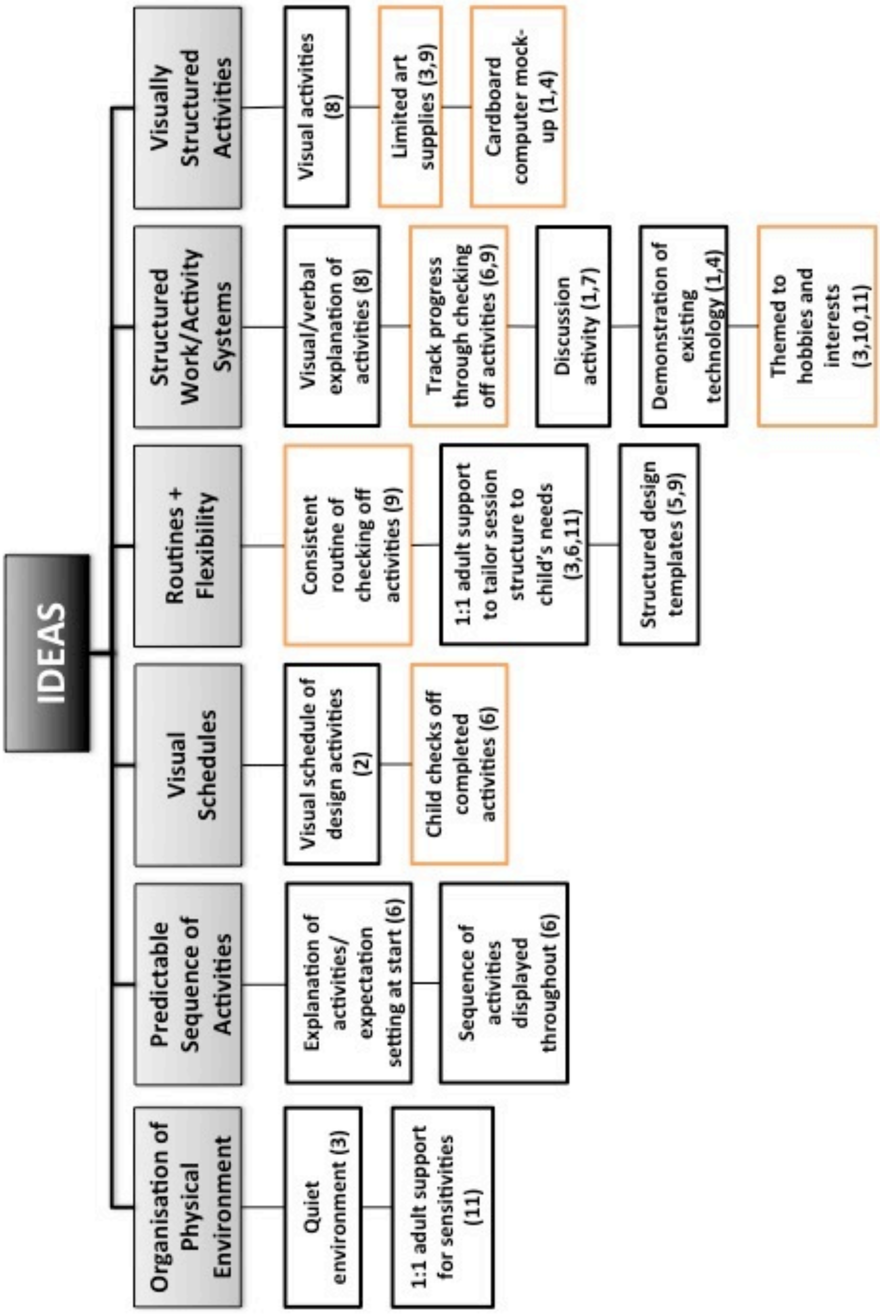


Figure 3.3 – Features of the IDEAS method[1] (novel features highlighted in orange)

The *initial* version of the IDEAS method has been described above. This approach has been trialled and refined across three separate studies, which are outlined below and discussed in further detail in the proceeding chapters.

[1] Numbers refer to the following TEACCH characteristics – (1) The Concept of Meaning; (2) Focus on Details; Ability to Prioritize the Relevance of Details; (3) Distractibility; (4) Concrete vs. Abstract Thinking; (5) Combining or Integrating Ideas; (6) Organising and Sequencing; (7) Generalization; (8) Visual vs. Auditory Learning; (9) Prompt Dependence; (10) Strong Impulses; (11) Excessive Anxiety

3.5 Overview of Studies and Methods

The final section of this chapter introduces the three central research studies presented in this thesis. Each study has a specific focus guided by the research questions defined earlier in this chapter, which include:

RQ1) Can children with ASD successfully generate and communicate *design ideas* and what implications do these ideas have in terms of designing educational technology for children with ASD?

RQ2) To what degree can children with ASD participate in the design of technology and taking account of existing theories of autism, how do *existing design methods* need to be adapted to enable this participation?

RQ3) What factors need to be considered to enable children with ASD to *collaborate* with others during design sessions?

To explore these questions a number of different methodological approaches have been employed, which include both observational and survey-based studies. An explanation of each of the studies undertaken is provided below, including a description of the participants involved, the data collection methods used, the overarching design task as well as the evaluation of the design outputs and the activities undertaken during each study.

3.5.1 Outline of Studies

To address the research questions in a thorough manner, a step-wise approach has been taken to establish the ability of children with ASD to firstly participate within typical PD activities and secondly to effectively work within a collaborative design environment as part of a design team. It was important to focus on these different abilities individually as it would be difficult to initially determine if the children's difficulty with collaboration was impacting their ability to undertake certain design tasks or if they were actually struggling with the creative demands of the task itself. With this in mind this thesis comprises three separate studies, which gradually increase the involvement of the children within the technology design process and include:

Study 1: Children undertake typical technology design activities individually. The first study focuses on the potential of children with ASD to individually undertake *typical design activities* and compares existing PD techniques against the new IDEAS method. If this is successful, then any issues with the design activities will be overcome, enabling PD elements for supporting collaboration to then be considered.

Study 2: Children design technology within a collaborative design environment. The second study focuses on the potential of children with ASD to undertake these design activities within a *collaborative design environment* whilst participating as part of a design team. This study uses a refined version of the IDEAS method and incorporates an adult responsible for building the resultant prototype technology product.

Study 3: Children design and build technology within a collaborative design environment. The third study focuses on increasing the *level of participation* within the design process by using a further adapted version of the IDEAS method. This is achieved by involving the children in the build phase of the prototype technology and also by giving them more responsibility in the organisation of the session activities.

The research questions provide a focus for the analysis of results from each of these studies. **RQ1** focuses on the design *contributions* made by the children, **RQ2** focuses on the degree of the child's *participation* within the design process, and **RQ3** focuses on the level of *collaboration* between the children and other design team members. Fig. 3.4 maps these research questions onto the level of involvement of the children within each study and the chapter reporting the corresponding findings.

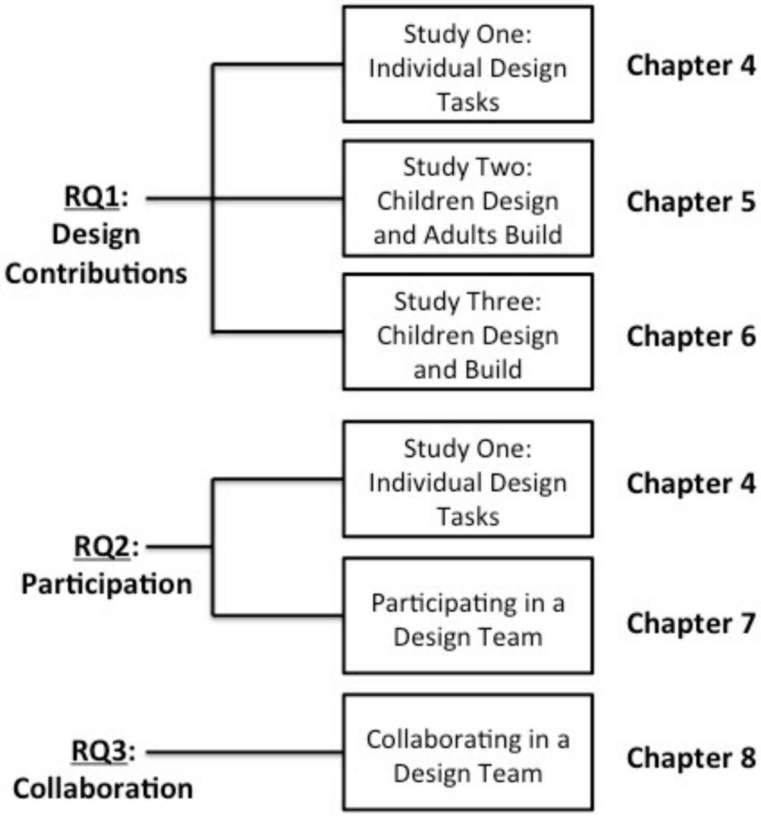


Figure 3.4 – Research questions, level of child participant involvement and related chapters

3.5.2 Educational Context

The studies reported within this thesis were undertaken at six schools, which included three specialist ASD schools and three mainstream secondary schools (see Table 3.3). All of the schools were non-faith and co-educational with the exception of ASD School 3 which was a boys school. The ASD schools were selected on the basis of their proximity to the university as well as the profile of the students that attended the school, i.e. HFA or AS rather than solely low-functioning, as the children needed to have sufficient communication skills to be able to participate in the studies. The mainstream schools were selected on the basis of their proximity to the university as well as the range of pupils that attended the school, i.e. mixed faith, sex, ability and household income. The head teachers at all of the participating schools were sent recruitment letters explaining the overall project in addition to what would be involved in the specific studies. One researcher also went to visit the majority of the schools (with the exception of ASD School 1, which was further away) in advance of the studies to meet with the teacher whom would be coordinating the pupils' involvement and to answer any additional questions they may have.

School	Location
ASD School 1	Vale of Glamorgan, UK
ASD School 2	Bristol, UK
ASD School 3	Somerset, UK
Mainstream School 1	Bristol, UK
Mainstream School 2	Somerset, UK
Mainstream School 3	Somerset, UK

Table 3.3 - Overview of Participating Schools

3.5.2.1 ASD School 1

This school is located in a town in the south of Wales and caters for a very wide range of ability and degree of autism. Over 100 pupils attend the school and they are aged 3-19 years. A small minority of the pupils board at the school from Monday to Thursday. A low proportion are from minority ethic groups, and almost a third of pupils are from households with low incomes. Pupils from this school participated within Study One only.

3.5.2.2 ASD School 2

This school is located in the south east of Bristol. It is a specific unit that caters for up to 35 students with ASD, and is attached to Mainstream School 1. The pupils have a wide range of needs, including comorbidity (areas associated with ASD), but the majority of the pupils have HFA or AS. The pupils attend lessons within a separate building that is located on the site of the mainstream school, but are also included within lessons at the mainstream school where possible. The proportion of students from low-income households is above the national average. Pupils from this school participated within Studies One, Two and Three.

3.5.2.3 ASD School 3

This school is located in a town in the south west of England and caters for pupils with HFA and AS. The pupils at this school are generally more academically able than the previous two schools, and the school's aim is to enable them to live more independent lives as adults. It is a purpose-built residential and day school attended by 50 boys aged 7-18 years, with over half of the boys boarding at the school on a termly or weekly basis. It is an independent school, with fees paid by the boys' families or through a local authority referral. Pupils from this school participated within Studies One, Two and Three.

3.5.2.4 Mainstream School 1

This school is located in the south east of Bristol, is an above average sized mixed comprehensive school and serves a mainly white British community. The proportion of disabled and special educational needs pupils as well as those from low income families is above average. The pupils are aged 11-18 years and are placed within smaller communities when they join the school, which intend to create a 'school-within-a-school'. These communities provide additional support for the pupils within smaller groups, with each community assigned a 'learning mentor' who is not a teacher to deal with pupil's problems. Pupils from this school participated within Studies One and Two.

3.5.2.5 Mainstream School 2

This school is located in a town in the south west of England and is mixed comprehensive school for pupils aged 11-18 years, and is larger than average. The pupils are from widely different backgrounds, with their circumstances being broadly average and the proportion of pupils from low-income households being below the national average. Less than 1% of pupils come from minority ethnic backgrounds. There are a smaller proportion of pupils with special educational needs than most schools. Pupils from this school participated within Studies Two and Three.

3.5.2.6 Mainstream School 3

This school is located in a small city in the south west of England, it is a mixed comprehensive school for pupils aged 11-18 years, and is larger than average. The majority of pupils are from a white British heritage and the proportion of pupils from a low income household is below the national average. The percentage of pupils with disabilities and/or special educational needs is also below average. Pupils from this school participated within Study One only.

3.5.3 Participants

Each study incorporated two groups of children. One group of children that had been diagnosed with HFA/AS by a clinician using the DSM-IV criteria and as a result of this diagnosis attended one of three participating specialist ASD schools. The other group consisted of TD children who attended one of the three participating mainstream secondary schools and were incorporated as a control group to provide a baseline in each of the studies. The participating children were all aged between 11 and 14 years and for each study the ASD and TD groups were matched as closely as possible on age, gender and verbal IQ, which was measured prior to the sessions being undertaken.

Verbal IQ was measured to ensure that the children all had a sufficient level of verbal ability to enable them to understand the session instructions, communicate their design ideas and ask for help if they experienced any difficulties. The Wechsler Intelligence Scale for Children (WISC), which is appropriate for use with children aged 6-16 years, was used to measure the children's verbal ability. The WISC was undertaken on a one-to-one basis with all of the children with ASD by a trained researcher and was undertaken under 'exam conditions' during maths classes with the TD children, with an adult available to provide support where necessary. The verbal IQ is calculated based on the children's current age, which enables the results to be directly comparable across age groups.

3.5.4 Design Task

The work in this thesis formed part of a wider project to design and develop an intelligent mathematics tutoring system for both children with ASD and TD children at Key Stage 3 (aged 11-14 years). The project was a joint collaboration between the departments of Computer Science and Psychology at the University of Bath, and the Research Associates working on the project participated in many of the sessions discussed in this thesis. For this reason it was important that the design task used in the studies had a mathematics focus.

It was decided to choose the design topic of a mathematics-based game and the design activities in all three studies focused on this topic to allow a more direct comparison across the various outputs. Computer games are a popular interest area across both ASD and TD child populations (Mazurek et al., 2011) and therefore games were chosen to form part of the design topic specifically to appeal to the participants in the study. As previously noted children with ASD can be uncooperative if a subject matter does not interest them (Attwood, 1998) and therefore there was a concern that a dislike for the design task itself could become a barrier to participation. This issue is discussed further in the limitations section within the concluding chapter of the thesis.

3.6 Summary and Next Steps

Within this chapter a review of the literature exploring the involvement of children with ASD in the technology design process has enabled a number of areas requiring further investigation to be identified. Many previous projects, which aimed to develop technology for an ASD population, have chosen not to involve the children directly within the design process. Instead researchers often observed their use of technology, involved their parents or teachers as proxies or involved the children themselves as testers/evaluators later in the process. A few examples of children with ASD undertaking a more involved within the technology design process have been identified, but there is little work exploring this involvement over a prolonged period or within a design team. The review also highlighted a number of ASD specific characteristics related to collaboration and creativity skills that could potentially impact the children's ability to participate within a PD process, which warrant further investigation. The findings from this review have subsequently helped to refine the set of research questions, which provide a framework for the empirical work within this thesis.

The second part of this chapter has focused on the development of a new PD method for an ASD population. This has involved the evaluation of existing PD methods and techniques for children using a set of criteria based on the TEACCH characteristics and resulted in the identification of a number of relevant features from existing PD methods as well as some novel features. These features have been integrated into the initial version of IDEAS, a new PD method specifically tailored for children with ASD, which is described and presented diagrammatically within this chapter. The following chapter will now introduce an initial trial of this method.

Chapter 4 Study One: Individual Design Tasks

4.1 Introduction to Study One

Study One was firstly concerned with **RQ1) Can children with ASD successfully generate and communicate *design ideas* and what implications do these ideas have in terms of designing educational technology for children with ASD?** It is important that participants are able to both generate and communicate their ideas during the technology design process as otherwise the extent to which they can contribute to, and impact design decisions, is severely restricted. Therefore in order to initially determine if children with ASD could potentially undertake a more involved role within the technology design process (i.e. sharing power with adults or leading the project), their ability to undertake typical PD activities such as idea generation and low-tech prototyping needed to be explored. It was established during Chapter Three, children with ASD could potentially struggle with the imaginative activities of idea generation and elaborating on these ideas and therefore this chapter addresses the sub-research question **RQ1a) Do children with ASD require any form of support in order to generate and/or communicate their design ideas?** This support needs to be balanced against providing sufficient creative freedom to enable the child to incorporate his or her own original ideas and not simply be guided towards an end-product that has been pre-determined by an adult. Therefore this is explored through the sub-research question **RQ1b) Are children with ASD able to generate design ideas, which are both appropriate and demonstrate some level of originality?**

Study One was secondly concerned with **RQ2) To what degree can children with ASD participate in the design of technology and taking account of existing theories of autism, how do *existing design methods* need to be adapted to enable this participation?** In order to address this the initial version of the IDEAS method was trialled alongside a method based on a subset of the techniques used within CI (Druin, 1999). These two methods were used to examine the ability of children with ASD to participate within design tasks guided by techniques aimed at TD children, and to establish if there was a need for the additional support incorporated into the IDEAS method.

The analysis of the study results was guided by **RQ1** and **RQ2**, exploring firstly the design *contributions* made by the child participants and secondly the degree of *participation* the children were able to undertake within the design session. As part of this the design outputs of the study have been examined to determine their wider appeal within the target user group of children with ASD and also resulting implications for a set of principles to guide the design of educational technology for an ASD population. A comparison has also been drawn between the participants using either the IDEAS method or the CI-based method to establish if additional structure and support is beneficial in enabling children with ASD to successfully participate more fully within the technology design process. It is important to note that this was not a direct evaluation to determine the best method, but rather an exploration of the type and frequency of support potentially required by children with ASD, to garner data about best practice as well as the practical application of each method.

4.1.1 Participants

Twenty children with HFA/AS and 20 TD children participated in the study, with the children divided into two groups. The children with HFA/AS were from ASD Schools 1, 2 and 3 and the TD children were from Mainstream Schools 1 and 3.

The difference between the ages and the verbal IQs of the ASD and TD children was not statistically significant (t^{19} = 0.2 & 0.4 respectively, both $p>0.05$). Each group contained 10 children with ASD and 10 TD children and were matched on age and gender across ASD and TD participants as well as between groups (all children aged 11-14 years, average 13 years, 18 males/2 females per group). Group One followed the IDEAS method during the sessions and Group Two followed a CI-based method. The difference between the ages and the verbal IQs of the IDEAS and CI groups was also not statistically significant (t^{19} = 0.6 & 0.9 respectively, both $p>0.05$).

Each child participated *individually*; the sessions were undertaken at the child's school in a separate room to their classroom and lasted no longer than one hour (see Fig. 4.1 for example setup). The children were taken out of class during lesson time (with prior permission from their teacher); the specific lessons that the children were missing depended on the school timetable and therefore varied between participants and schools. No time limit was imposed and when the child completed all of the activities they were free to return to class. The same adult facilitator ran each session, and their role was to introduce the tasks and provide additional explanations if the child experienced any difficulties, but not directly participate in the sessions. The facilitator only intervened if the child was visibly experiencing difficulties (i.e. not making any progress within the activity) or directly asked for help/further explanation. There was also an adult note taker in the room, who was directed to take written notes to document what happened during the session. The role of both adults was explained at the start of the session by the facilitator and the note-taker remained silent throughout. The design task that all of the children were set was to design a new maths game for their peers.

Figure 4.1 - Example Study One setup

4.1.2 Data Collection Methods

During the first study both the adult facilitator of the sessions and a non-participating adult note-taker took written notes of what they observed during the sessions, particularly related to any difficulties the child may have experienced. The adult note-taker also took photographs at regular intervals to document the different tasks, however these photographs were always taken from behind to protect the identities of the participating children.

Prior to the sessions the 13-point ethics checklist required by the University of Bath Computer Science Department when involving participants in research was completed and can be found in Appendix B. The wider project that this work formed part of also met the British Psychological Society ethical code and was approved by both the Department of Psychology and University of Bath ethics committees.

4.1.3 Procedure

4.1.3.1 Group One: The IDEAS method

The children in Group One individually followed the IDEAS method. This consisted of the following activities:

1. *Introduction* - The adult facilitator verbally introduces the session, explaining who they are and what the role of the note taker is, the purpose of the project and what the child will be expected to do during the session. The activities are explained one by one, and pointed out on the visual schedule. The child is then asked to check off the first activity by putting a tick next to the 'Introduction' activity on the visual schedule.
2. *Discussion* - The facilitator initiates a discussion with the child, asking them about their experiences and opinions of their maths and ICT lessons in school. The facilitator then demonstrates two existing online maths games, suitable for a Key Stage 3 level maths or below, and asks the child what they like and dislike about the games. Within this study the games included the Train Race and Math Slalom (see Fig. 4.2). The Train Race is a non-animated one-player game and involves calculating the median and range of the different train journeys. Math Slalom is an animated one-player game that involves directing the skier through the slalom poles that display numbers that can be added, subtracted, multiplied or divided together to equal the number at the top of the screen. The child is then asked to check off the second task by putting a tick next to the 'Discussion' task on the visual schedule.

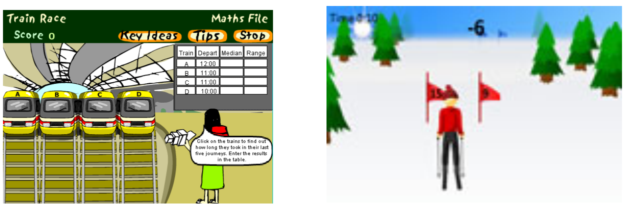


Figure 4.2 - Demonstration maths games: Train Race (left) and Math Slalom (right)

3. *Idea Generation* - The child is given a paper-based template (see Fig. 4.3) and asked to generate his or her own ideas for a new maths game. If the child only generates one idea the adult prompts the child to think of multiple ideas if they are able to. If the child is unable to generate any ideas at all, the adult provides them with an alternative template containing example ideas and space to also add their own if they can (see Fig. 4.3). Once the child cannot think of any more ideas they are asked to evaluate each idea by giving it a rating out of 10. It is explained that 1/10 = an awful idea and 10/10 = a brilliant idea. There is space within each idea box on the template for the child to write down their rating. The child is then asked to check off the third activity by putting a tick next to the 'Idea Generation' activity on the visual schedule.

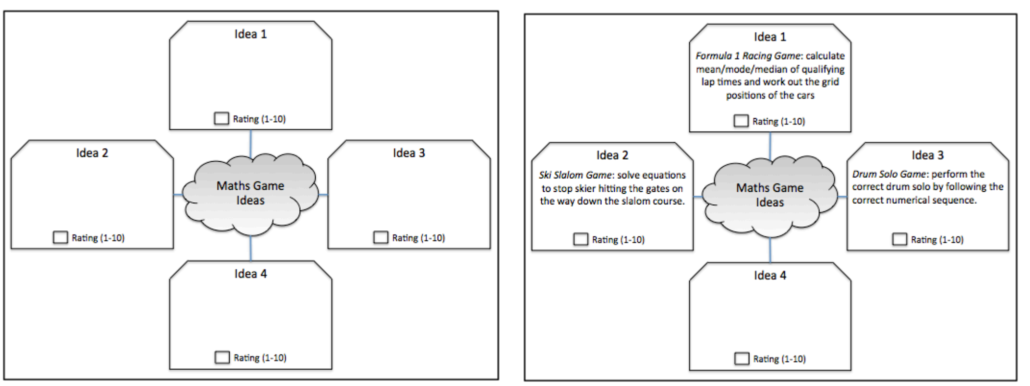


Figure 4.3 – Idea Templates: Basic level of support (left) and High level of support (right)

4. *Design Development* - The child is asked to pick their favourite maths game idea and is then provided with a limited selection of art materials (e.g. coloured pencils, felt tip pens, paper, glue) and a paper-based template (see Fig. 4.4) on which to draw out the interface design of their game. The child is also provided with a selection of pre-drawn images based on the typical hobbies and interests of both ASD and TD children. These were based on a hobbies and interests questionnaire undertaken in the schools as part of the wider mathematics tutoring system project prior to the sessions taking place. If the child demonstrates any difficulties with this activity the adult facilitator can provide them with an alternative template, either a medium level of support version providing a part-completed interface game design or a high level of support version providing a fully completed interface game design, but both with space for the child to make their own modifications or additions to (see Fig. 4.4). Once the child has completed their interface design they are asked to place their paper-based template in the cardboard mock-up computer and verbally explain how their game would work on the computer. The child is then asked to check off the final activity by putting a tick next to the 'Design Development' activity on the visual schedule.

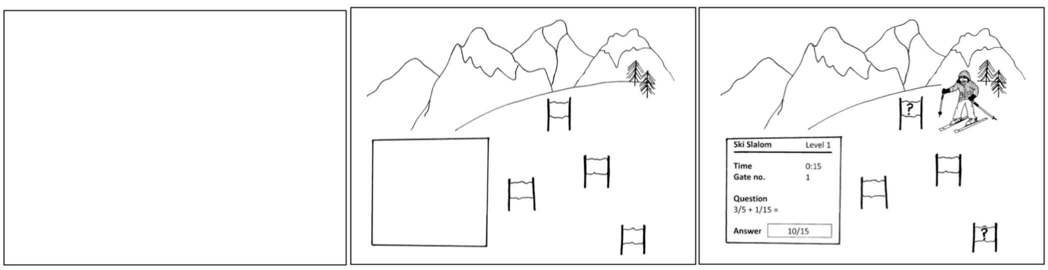


Figure 4.4 – Interface Design Templates: Basic level of support (left), Medium level of support (middle), High level of support (right)

4.1.3.2 Group Two: CI-based method

The children in Group Two individually followed a method based on some of the activities incorporated within CI (Druin, 1999), and which did not provide any additional support if the child experienced difficulties. It is important to note that the activities did not follow the CI method exactly as it typically is used with a design team, but it was instead adapted for use with individual children. The CI-based method consisted of the following activities:

1. *Introduction* - The adult facilitator verbally introduces the session in a similar way to the IDEAS method, but there is no additional visual support for this introduction.

2. *Sticky Notes* - The adult facilitator demonstrates two existing online maths games, suitable for Key Stage 3 level maths or below. Within this study the demonstration games included the Train Race (as described above) and Half-Court rounding, which is an animated one or two-player game that involves answering maths questions to shoot the basketball in the hoop correctly (see Fig. 4.5). The facilitator then asks the child to write their likes, dislikes and suggested improvements on colour coded post-it notes, placing them in the corresponding column on a paper-based table (see Fig. 4.6).

Figure 4.5 - Demonstration maths games: Train Race (left) and Half-Court Rounding (right)

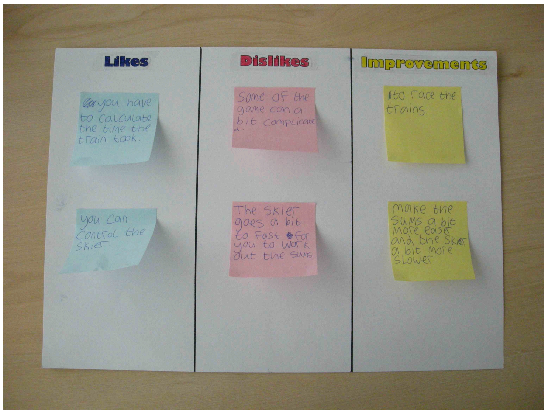


Figure 4.6 - A child's feedback on the demonstration games using the 'Sticky Notes' activity

3. *Brainstorming* - This activity is not operationally defined in the CI literature, but is tailored to individual projects. In this approach the facilitator provides the child with a blank piece of paper on which to write their own ideas for a new maths game and some suggestions of possible things to think about such as the name and activity the game could perform. If the child can only think of one idea then the facilitator prompts them to generate multiple ideas if possible, but if the child cannot think of any ideas they are not provided with any additional support.
4. *Bags of Stuff* – The child is asked to choose their favourite game idea, or if they were unable to think of an idea to choose their favourite example game from the second activity to design (or redesign) the interface for. The adult facilitator provides the child with a selection of art materials including felt tip pens, coloured pencils, glue, coloured paper, lolly sticks and balls of fluff. The child is then asked to create a low-tech prototype of the game interface. Once the child has completed their interface design they are asked to verbally explain how the game would work to the adult facilitator.

4.1.4 Evaluation of Design Outputs

One of the contributions of this thesis is to provide guidelines for running successful PD sessions for children with ASD. Therefore one approach to determining the success of the IDEAS method was to evaluate the design outputs from each of the studies. This was done by involving a number of non-participant ASD and TD children from the same schools as the participant children, to determine the wider appeal and potential success of the game ideas within the children's peer group. These children were aged between 10 and 15 years and were matched across groups where possible, however their verbal IQ was not measured prior to the evaluation sessions. After the completion of Study One, 20 children with ASD (aged 11-14 years, average 13 years, 16 male/4 female) and 27 TD children (aged 11-12 years, average 12 years, 19 male/8 female) were shown a set of 40 cards (see Fig. 4.7), which had been randomly shuffled to reduce any order effects. Each card showed one of the 40 final interface maths game designs produced by the participant children, along with a short description of the game based on the explanation the child gave at the end of the design session.

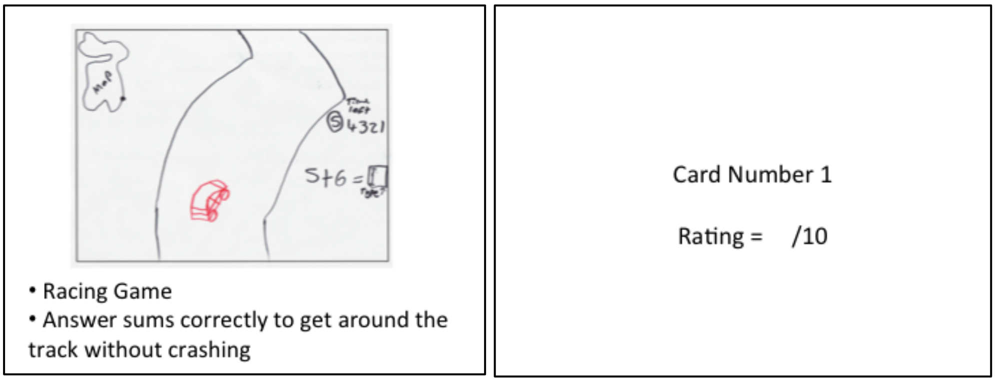


Figure 4.7 – Example card showing final interface game designs (front and back)

This evaluation activity was undertaken with one whole class of TD children. They were instructed to "Look through each of the cards and give each game idea a rating out of 10 based on how good or bad you think the idea is for a maths game, with a rating of 1 meaning a really bad idea and a rating of 10 meaning a really good idea." They also were provided with an additional sheet of paper on which to write all of their highest rated cards and reasons for choosing those games as the best ones.

The same evaluation activity was undertaken individually with the children with ASD. They were shown one card at a time by an adult researcher and then asked "Do you think this is a good or bad idea for a maths game? Show how much you like or dislike the game by placing it under the number rating out of 10 you would give." (see Fig. 4.8 for setup). They were allowed to move the cards after placing it down if they wished. They were then asked what they liked about each of their highest rated cards and the researcher noted this down. This activity was undertaken individually with the ASD group to ensure they clearly understood the task, to make it more visual by providing a structured way for them to compare the different designs in a concrete way and also to provide additional support for any reading/writing difficulties.

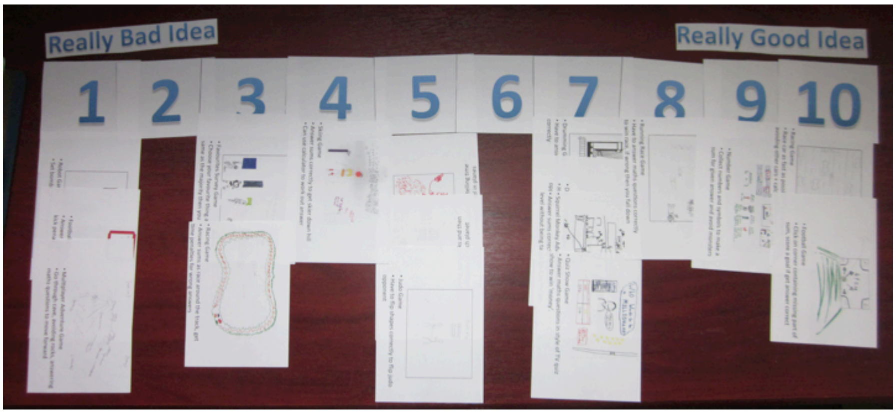


Figure 4.8- Card rating activity setup undertaken with ASD group

4.1.5 Outputs and Analysis

In order to address **RQ1** and **RQ2** from a design task-focused perspective the outputs from Study One were analysed (see Table 4.1). The analysis of each output has been guided by a series of sub-research questions, which are noted within Table 4.1 and discussed in further detail on the following page.

Output	Sub-Research Question
Written notes from adult facilitator and observer	RQ1a, RQ2a, RQ2b
Completed game idea templates	RQ1a, RQ1b, RQ1c
Completed interface game design templates	RQ1a, RQ1b, RQ1c
Non-participant children's ratings/ranking of final game prototypes	RQ1d

Table 4.1 – Outputs of Study Two and related sub-research questions

RQ1a) Do children with ASD require any form of support in order to generate and/or communicate their design ideas?
To address this sub-research question the written observations from both the adult facilitator and observer were analysed and any difficulties the children experienced during the process of generating or communicating ideas were noted. These written notes were also examined in conjunction with the completed templates to determine the type and level of support that each child required to complete the design task successfully.

RQ1b) Are children with ASD able to generate design ideas, which are both appropriate and demonstrate some level of originality?
To address this sub-research question the completed idea and interface design templates were analysed to establish the appropriateness and originality of the children's ideas. Firstly each completed game interface design template was compared against the initial design brief to determine if it fulfilled the criteria of being both a game and containing some form of maths. Secondly to determine the degree of originality within the children's chosen game ideas, they were compared against the demonstration games and the example games within the templates (provided to the children who experienced difficulties within the IDEAS method) as well as known existing games the children played.

RQ1c) What specific implications do these design ideas have for designing educational technology aimed at an ASD population?
To address this sub-research question the completed idea and interface design templates were analysed to establish any visual design, feedback and guidance, and motivation and

engagement preferences, and based on these preferences what the resulting implications for educational technology design may be.

RQ1d) Do these design ideas appeal to other children within the ASD population?
To address this sub-research question the completed interface design templates along with a short description of the game idea were shown to a group of children with ASD and a group of TD children (both groups had not participated in the study) to establish their opinions of the different maths game ideas. The results of this evaluation activity were analysed to determine which game designs were most appealing to each peer group.

RQ2a) What role do adults need to play to best enable the participation of children with ASD within the technology design process?
To address this sub-research question the written notes from the adult facilitator and observer were analysed to identify any instances where the facilitator had to intervene to support the child's participation and what type of intervention they had to make.

RQ2b) What are the most effective techniques for engaging children with ASD as active participants within the technology design process?
To address this sub-research question a thematic analysis of the written notes from the adult facilitator and observer was undertaken to identify any factors which impacted the children's engagement or disengagement within the task and potential reasons for this.
The findings from this analysis of both the CI-based and IDEAS methods are described in more detail below.

4.2 Design Contribution Findings

4.2.1 Support for Idea Generation and Communication

This section addresses the sub research question **RQ1a) Do children with ASD require any form of support in order to generate and/or communicate their design ideas?** Firstly the written observations made by both the adult facilitator and note-taker during the sessions were examined to establish if there were any specific difficulties with *generating or expressing* ideas. Any identified difficulties were then further examined to establish if any additional support was required to enable the child to successfully complete the activity or if these difficulties became a barrier to the child completing the activity. There was a marked difference in the ability of the children with ASD and TD children to generate and develop their own maths game design ideas. All of the TD children, using both IDEAS and CI-based methods, were able to successfully generate at least one maths game design idea and develop this into a paper-based interface design. There were only a few observed difficulties with this group, which included:

- Six children needing some form of *additional verbal explanation or prompting* from the adult facilitator (two using IDEAS and four using CI).
- One boy using the IDEAS method seemed to lack confidence in his own abilities and required additional explanation and encouragement from the facilitator to begin generating his own design ideas.
- Another girl using the CI-based method took a long time to generate any ideas and did not volunteer to verbally share or write down her ideas when she had, being prompted by the facilitator to do so.

There were also a few minor issues within the TD group related to the method of expressing their ideas during the session:

- The experimenter had to *provide additional explanation* to one boy on how to document his ideas on the template used in the IDEAS method.
- Two participants using the CI-based method also needed *further explanation* about how they should document their ideas on the blank paper.

- Another boy using the CI-based method had to be *prompted to write his ideas down*, as he preferred to share them verbally with the facilitator.

In contrast to the minimal adult verbal explanations/prompts needed within the TD group, some children with ASD required *explicit structured support* to enable them to progress in the design activities. Twelve out of 20 children with ASD required some *form of additional support* from the adult facilitator, which included:

- Some cases where the children were able to progress with *solely verbal support* from the facilitator. Three participants using the CI-based method initially struggled to generate ideas with no built-in support to mitigate this issue, the adult facilitator simply provided *verbal encouragement* and *suggested basing their idea on one of the existing games* demonstrated during the previous activity. Two of these participants were eventually able to generate their own game idea, generating the game concept during the low-tech interface design ("bags of stuff") activity. The other boy made some additions and modifications to one of the existing games, drawing out his own version of the interface (see Fig. 4.9).
- Two boys using the IDEAS method were confident expressing themselves verbally and were able to describe important aspects to make a successful game, but struggled to come up with their own game concept. One boy who demonstrated a strong interest in computer games was then able to incorporate these ideas into an existing game he was familiar with during the design development activity. The other boy did not like playing games and so needed the *high level template* incorporating an example interface design for a game, which he could then incorporate his ideas into (see Fig. 4.10).
- There were also some minor issues with expressing ideas, one child using the IDEAS method needed *clarification* about whether he was supposed to write or draw his ideas.
- Also two participants (one using IDEAS and one using the CI-based method) needed *support for writing* ideas due to general difficulties with spelling and dyslexia.

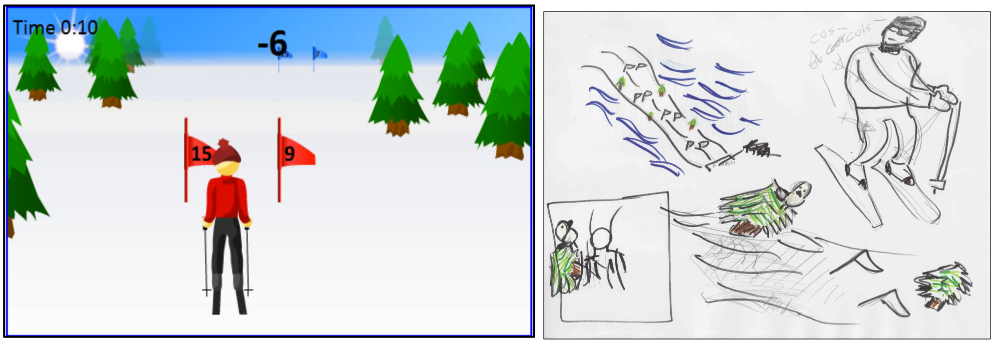


Figure 4.9 – Example maths game (left) and new version designed by the child with ASD using CI-based method (right)

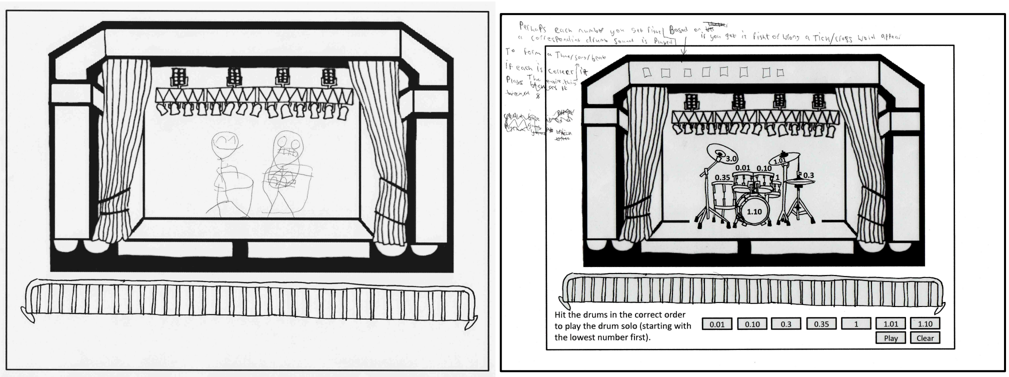


Figure 4.10 – Completed medium (left) and high level (right) support templates from IDEAS method

In addition to the participant mentioned above there were five further children with ASD using the IDEAS method who required *high-level template-based support* during the idea generation activity, with one child also requiring this support during the design development activity. After being provided with a template containing three example maths game ideas, one child was then able to generate his own maths game idea and two children were able to use one of the *example ideas as a basis* for their interface design to expand upon. However, two children were unable to complete the task successfully even with the high level template-based support:

- One boy wanted to use an existing game that was not a maths-based game. He was not prepared to deviate from the original game and so his idea was simply a carbon copy of this existing non-maths game.
- The other boy had asked to play the demonstration maths game during the previous task and had been unable to answer any maths questions correctly, which then proceeded to impact his engagement in the rest of the session. He was unable to generate any of his own ideas even with the examples ideas as a prompt simply writing "I hate the basketball" (the game he had played). Although he did eventually select a favourite example game, he struggled to develop it into a maths game using the medium level support interface design template (e.g. Fig. 4.10) simply drawing on two game characters playing the drums and not including any maths in his idea. This highlights a difficulty in selecting the appropriate level of support in advance of the activity and a potential need for the level of support to be adapted during the activity.

One interesting observation related to the expression of ideas was that there was a variety of approaches employed by the ASD and TD groups using the CI-based method including a *spider diagram of game ideas*, simply *the writing name of games*, writing *detailed descriptions* of game ideas and *drawing out* games (see Fig. 4.11). However, all of the children using the IDEAS method wrote out their game ideas within the boxes provided on the template (see Fig. 4.12). The template provided more structure to help *guide expression of ideas* and to prevent the concerns about being presented with a blank piece of paper. A consequence of this is that it did not encourage *different forms of expression*, which may be partly due to the boxes being too small to write long descriptions or to incorporate a detailed drawing. Therefore this may disadvantage those children who prefer to *express themselves in alternative ways*. However, there are still potential issues with simply providing the child with a *blank piece of paper*, as several children with ASD using the CI-based method struggled with this and one child was unable to write or draw anything on the paper. This indicates that the CI-based method would be successful if the child is good at idea generation/expression, but poor if *additional support* is needed in these areas.

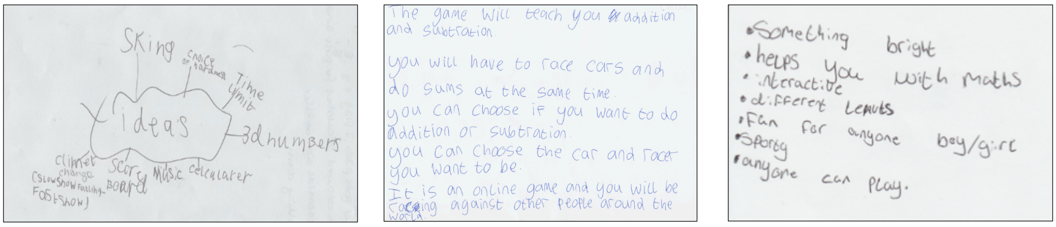


Figure 4.11 – Different forms of idea expression used in CI-based method

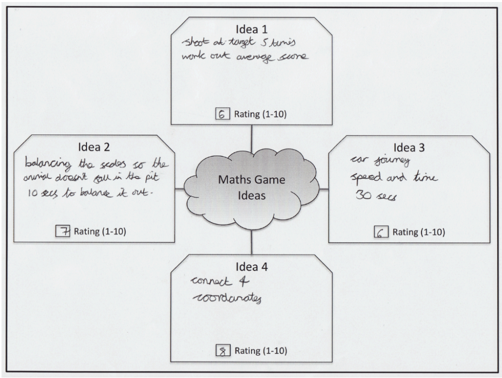


Figure 4.12 – Basic level support template for idea generation used in the IDEAS method

4.2.2 Appropriateness and Originality of Ideas

This section addresses the following sub-research question **RQ1b) Are children with ASD able to generate design ideas, which are both appropriate and demonstrate some level of originality?** It is important to establish the ability of children with ASD to work within a given design brief and also to generate original ideas; otherwise the value of their contribution to the technology design process may be very limited. Therefore in order to address this research question the outputs of the idea generation activities were additionally analysed to establish the participants' ability to generate **appropriate** ideas that fulfilled the original brief (i.e. a game that contained some form of maths content).

Three TD children, all using the CI-based method, exhibited difficulties with generating an appropriate idea. One boy was able to generate different game elements, including how the maths content could be incorporated, but struggled to generate a game concept and specific maths content, preferring to concentrate on ideas for the menu screen and various options that could be included in the game. However, he did eventually incorporate a basic idea for the game and maths content during the "bags of stuff" activity. Another boy similarly generated ideas for different game aspects during the idea generation task, but was more successful in turning these ideas into an actual game concept during the "bags of stuff" activity. Finally one boy had to be *prompted by the adult facilitator* to include a game component within his ideas, which were initially focused solely on ideas for the maths content.

Within the ASD group nine children had difficulties generating appropriate ideas, five children using the IDEAS method and four children using the CI-based method. There were a number of reasons for these difficulties. Within the IDEAS method one girl got distracted by the pre-drawn images provided during the design development activity and *the adult facilitator had to remind her* that her game needed to include maths. One boy was fixated on his favourite computer game, which did not include maths and so was resistant to incorporating maths into his idea. Another boy who did not include maths in his game idea (as mentioned earlier) was affected by struggling to understand a demonstration maths game, and so this may have affected his willingness to include maths within his own game.

Two further boys with ASD had similar issues to some of the TD children in that they were focused on different higher-level game elements for instance stating that the game "would need some form of reward system/instant feedback", rather than generating an actual game concept and specific maths content. Although one of these boys was then able to incorporate an appropriate game concept during the design development activity unsupported.

This same issue occurred within the CI-based method with three other participants, but they were also able to go on to develop these game element ideas (or in one case maths content ideas) into an appropriate game concept during the "bags of stuff" activity. This suggests that the children were able to initially only develop high-level ideas that then became instantiated later in the design session. Lastly one other boy with ASD became very involved with his game idea and forgot about the maths content, having to be *prompted by the adult facilitator* to incorporate this.

The findings described above indicate that it could be possible to facilitate difficulties with idea generation both by a *process change to an alternative design activity* or by *adult intervention*, providing a recap of the design task or example idea components to ensure the final design fulfils the original brief. The inclusion of this form of structure and support may also be appropriate to incorporate for a subset of the TD children.

The outputs from the interface design activity were analysed to address the second part of **RQ1b)**, to explore the extent of the **originality** of the children's ideas and how much they were influenced from being shown existing maths games prior to the idea generation activity. It was observed that the final game designs of half of the children with ASD across the two methods were influenced by either one of the *demonstrated existing games*, another *existing game* they had played outside of the session or the *template example game ideas*. Two children with ASD using the CI-based method used one of the example games as a basis for their interface design, one boy based his idea on the storyline of a film and another boy generated an extremely detailed game idea that bore many resemblances to an existing game called "World of Warcraft". However, he was then able to further develop this concept to incorporate maths. Within the IDEAS method five children with ASD used the example ideas incorporated into the template based support as a basis for their interface designs, one boy used an existing non-maths game as his idea and another boy incorporated his game element ideas into an existing game that he had played outside of the session.

In comparison only three TD children appeared to be *directly influenced by existing games* and none of their final interface designs were based on the maths games demonstrated during the sessions. Two children using the IDEAS method and one child using the CI-based method were inspired by games that they had previously played outside of the session. However, these were not originally maths games and they still demonstrated the imaginative ability to think of a way to incorporate maths into these games. This highlights a difficulty experienced by the children (particularly those children with ASD) in generating original design ideas completely from scratch. The demonstration of example games may allow these children to still generate original elements to build upon these existing ideas, but they may struggle when participating in idea generation activities that require "blue-sky thinking".

4.2.3 Educational Technology Design Principles

This section addresses the following sub-research question **RQ1c) What specific implications do these design ideas have for designing educational technology aimed at an ASD population?** The concept of using a set of design principles to help inform the design of children's technology was discussed in the Chapter Two. A set of existing design principles along with specific considerations related to designing for children with ASD was presented. These principles are discussed further in terms of the implications based on the findings from Study One. The full principles are as stated in Chapter Two and have been summarized by high-level category headings below, which include visual design, feedback and guidance, and motivation and engagement. It is important to note that as the children only produced a single-screen paper based interface design of their game there may have been certain design elements such as those related to sound and navigation between screens that had not been considered due to the form of the design task. The final designs produced by each of the children may also be restricted by their creative ability and drawing skills, and therefore the findings from this analysis simply provides an initial indication of design principles rather than any firm conclusions. These principles will be explored in greater depth during Study Two and Three, which are discussed in later chapters.

4.2.3.1 Visual Design

The majority of the children in both groups incorporated some form of *animation* into their games. This was generally centred around the animation of the central game character or feature. For instance in a racing game the car moving around the track or in a football game the ball going into the goal, which encouraged the users attention to be focused on the correct area of the interface, with minimal additional distracting animations. This follows design principle 1.1, which advises against the use of excessive animations. Children often express preferences for extremely colourful interfaces. However, the majority of children from both groups did not include any *colour* in their final interface designs or only used very limited colours. Additionally many of the children's interface designs included very *simple graphics*, with only seven children with ASD and six TD children incorporating more complex graphics to help set the scene of the game, which included features such as a cityscape, a maze, an airport and a space scene. The exclusion of colour and more complex graphics from some of the children's designs may be related to their drawing skills, with many children expressing concerns about their ability to draw and therefore no firm conclusions can be made in relation to this aspect of the interface. During the evaluation activity a minority of the non-participant children from both groups mentioned the look of the game interface designs with two children with ASD and six TD children saying they rated a game highly because it looked good. Although again the quality of the children's drawing could have impacted this result and the appeal of the visual design may increase in a more polished form.

Approximately half the children from both the ASD and TD groups included *symbols* within their interface designs, which were frequently maths-based symbols. However, some of the TD children included a wider range of other symbols including hearts to represent lives, a tick/cross to represent positive/negative feedback, warning signs and also question marks to indicate an answer is being asked for. Only two children with ASD included other symbols, using a tick/cross or smiley/sad faces for positive/negative feedback. This indicates that potentially more basic and widely used symbols should be used for children with ASD and it would be important to involve children with ASD in the decision over which symbols to incorporate to ensure they would generally be understood. This follows design principle 1.3, which suggests abstract metaphor representations should be used with caution for TD children and avoided for children with ASD. Twelve children with ASD and 16 TD children included *text* within their interface designs. The children with ASD mainly used the text to label elements of their interface, however some children also used text to indicate certain actions within the game, to title their game, to show additional information about the game such as player statistics and also to give positive/negative feedback. The TD children similarly used the text to label elements of their interface and also for the other reasons stated above, but additionally used it to give instructions/rules of the game or provide the player with additional guidance during the game. The children with ASD did not include any large chunks of text, such as the instructions/rules that the TD children did, with some children exhibiting difficulties with reading/writing text during the design session. This highlights a need to reduce the amount of text incorporated into an interface designed for children with ASD, following design principle 1.6, which states that text should be minimised.

There is a tendency among teenagers, particularly males, to show a liking towards *violent computer games*. Therefore the appropriateness of the game designs is of particular concern when designing with and for this age group. A minority of the game designs included some form of violence such as guns or fighting, and were produced by four children with ASD and one TD child. These game designs were popular during the evaluation activity with the non-participant children; with four of the five designs, which incorporated violence, being included in the top 10 designs for both ASD and TD groups. In addition to this five children with ASD and 10 TD children gave the inclusion of violence as a key reason for liking the game designs. In this case it is important for the adult technology designers to balance the need to appeal to the target audience with the age appropriateness of the content. Designers should recognise that although violence-related features may be appealing to this age group the design principle of ensuring the design is age appropriate, and therefore excluding portrayals of violence, should still be followed.

4.2.3.2 Feedback and Guidance

The majority of the children in both groups designed a *highly structured* game where the player's only interaction with the game was to input the answer to the maths question or have some form of limited control over the main game character. In general the player did not have much control within the maths game designs, with the exception of the designs of four children with ASD and three TD children who allowed the player to control things such as the level of difficulty, the selection of the player character or the maths topic. This indicates that the majority of children may prefer a more structured environment, which follows design principle 2.1, which suggests that a structured environment is preferable for children with ASD. However, it may be appropriate to offer some options for customisation to allow the children to tailor elements to their individual preferences. This is because in designing their own game the children may have already set all the options based their preference and not considered that others may have different preferences.

None of the children with ASD mentioned anything about *help or helper characters* within their game designs. Although they may not have considered the need for this, as they themselves would have fully understood how their game worked. Three TD children mentioned help, with two children including explanatory text within the interface and one child including a tutorial video, but no children mentioned any kind of helper character. There may not be a need for any substantial form of help within simple maths games, but the level of help required by different children would still need to be established after the game design had been transferred onto the computer.

The children's game designs included a variety of ways for providing the player with *positive or negative feedback*. Amongst the ASD group the most popular method of positive feedback was simply to be allowed to continue the game or move closer to the game objective in some way if you got a correct answer. A minority of the TD children also suggested this method of positive feedback. Amongst the TD group the most popular method of positive feedback was generating a direct action on the game such as scoring a goal or hitting a target. Other methods of positive feedback suggested by both the ASD and TD groups included progressing to a harder level, avoiding negative consequences or graphical/sound-based feedback. Fewer children incorporated ideas for negative feedback, but the most popular method for providing negative feedback *amongst the other children* in both groups was for a negative event to be triggered giving an incorrect answer such as losing progress made, going back to the start of the game, receiving a time penalty or losing lives. It appears that within the ASD group simply avoiding the disruption of the gameplay and making progression in the game could potentially be sufficient enough feedback that they are doing well. The negative feedback also frequently fit into this progression-based model, with the loss of progress indicating incorrect answers. This type of feedback means that the focus is not removed from the task during the game and also the player is not explicitly criticised for getting a question wrong. However, there are no suggested strategies within the game designs for if a child continually gets the questions wrong and is unable to make any progress, so this would need to be further investigated.

4.2.3.3 Motivation and Engagement

One of the key reasons for using computer games in education is to make learning about certain topics more *fun*. It is interesting to note that the responses from the TD children during the evaluation of the game designs highlighted the importance of fun within games, with 78% of the children giving 'fun' as a reason for liking one of the game designs and this being the most popular reason for liking a game. In contrast only 25% of the children with ASD gave this as a reason for liking a game design and a number of other reasons being more frequently stated. Therefore, it may be important to ensure that other factors in addition to fun are considered when designing for an ASD population and also that some children with ASD may have a completely different concept of what is fun to many TD children.

The majority of the children did not include an explicit *reward* for completing their game and the main reward for answering all of the maths questions correctly in both groups was that the player would achieve their objective or beat their opposition. Within the ASD group one child suggested gaining points and another wanted a sound-based reward. A minority of the TD children similarly suggested gaining something such as points or money. Therefore within a game environment simply 'winning' the game may be a sufficient reward for many children and external rewards may not be as important for motivation as within other types of educational technology. The results of the evaluation also provided a similar indication with the most popular reason for rating a game highly within the ASD non-participant group (nine children) being because they liked the game objective and therefore achieving this objective may be rewarding for these children. However, this was not true of the TD non-participants with only one child mentioning this as a reason for a finding a game appealing.

Few children mentioned any form of *personalisation*. A minority of the children with ASD suggested personalising the colours or clothes of the player and a limited number of the TD children suggested personalising the game environment. However, it is important to bear in mind that the children were already personalising the game design to their own preferences during the design development activity. Therefore, particularly within the ASD group who have difficulties understanding what others are thinking, they may not have considered that these might not match the preferences of others and they may want an option to change these preferences.

4.2.3.4 Maths game type

As the design task incorporated two specific requirements for the design idea (to incorporate both a game element and maths content) it is also useful to consider the approach the different groups of children have taken to including both of these elements.

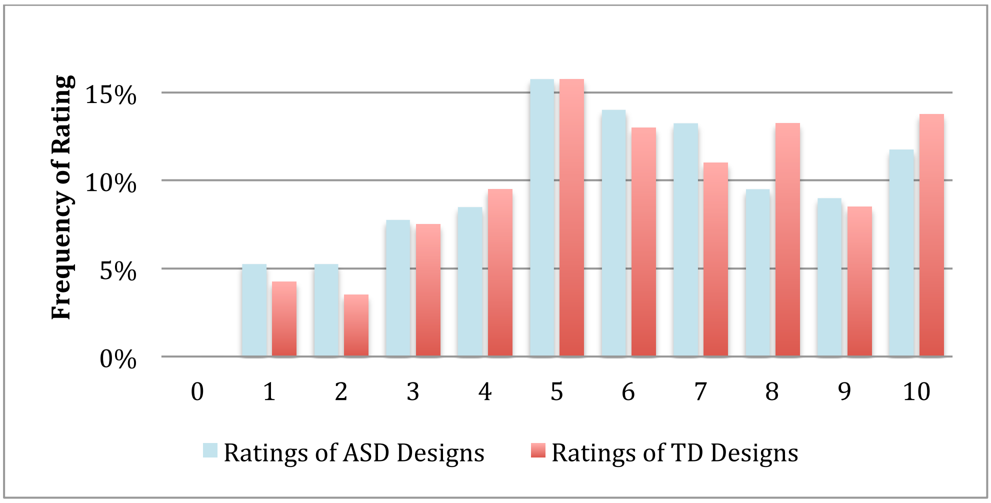
Kafai (1995) defines two types of game in relation to the maths fraction games built by the children that participated in her research work. The first type is a 'game world' where the game is at the centre and the success of the player is dependant upon answering the maths questions correctly to continue or complete the game. The second type is a 'microworld' where the maths is in the foreground and is fundamental to the game concept, where the player can interact with different artefacts that represent the maths topic. Microworld-based games designs were slightly more common within both groups, with 10 children with ASD (out of the 18 children who were able to integrate maths appropriately within the game) and 11 TD children choosing to design a game using this approach. This indicates that the educational content may not necessarily have to be 'hidden' within the game in order to make the games appealing for the children to play. The majority of the games extrinsically integrated the maths content within the game and only one boy with ASD intrinsically integrated the maths into his airport simulation where the player had to calculate the amount of fuel required for the planes or the timings of the take-off/landings. The other children tended to simply integrate the answering of basic sums within the game. It is difficult to determine if this would be their preference or if they simply lacked the ability or the will to invest the extra effort required to integrate the content within the game in a more complex way. In order to explore the preferences of children with the ASD population in more depth, removing the issue of the children's ability to produce the design idea, the following section discusses the results of an evaluation activity with children who did not participate in the design sessions.

4.2.4 Appeal of Design Contributions

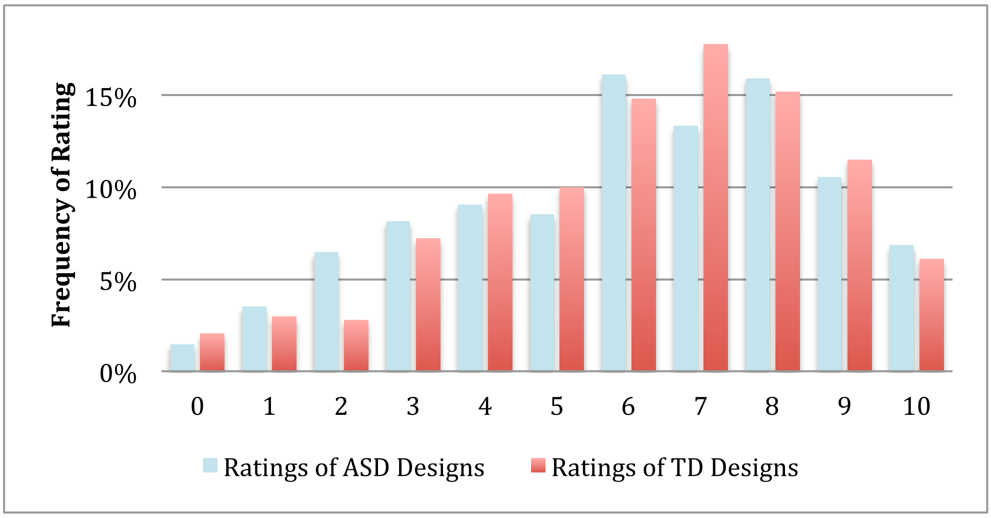
This section addresses the following sub-research question **RQ1d) Do these design ideas appeal to other children within the ASD population?** The evaluation activity undertaken with 20 children with ASD (from ASD Schools 2 and 3) and 27 TD children (from Mainstream School 2) helped to address this question and establish if these game designs produced by the child participants appealed across their wider peer group. This is important as the participant children are acting as representatives for their peer group (who are the target user group) during the PD process. Both ASD and TD groups firstly rated each game design out of 10 based on how much they liked it. The children were also asked to provide reasons for what they particularly liked about the games they gave their highest ratings to. On average there was little difference between the ratings given to the game designs produced by children with ASD or TD children (see Table 4.2). Although it is important that the specific preferences of each group are examined in more detail before any firm conclusions can be made.

	Average Rating from children with ASD	**Average Rating from TD children**
Game Designs by children with ASD	6.1	6.0
Game Designs by TD children	6.3	6.2

Table 4.2 - Average ratings out of 10 of the children's final maths game interface designs



Graph 4.1 – ASD Group ratings of maths game interface designs produced by both children with ASD and TD children



Graph 4.2- TD Group ratings of maths game interface designs produced by both children with ASD and TD children

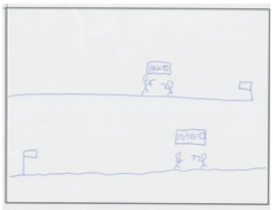
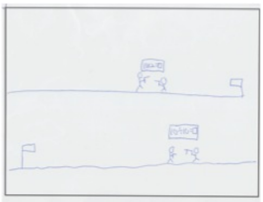
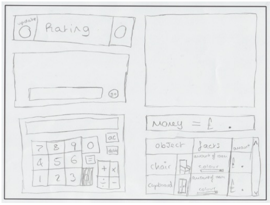
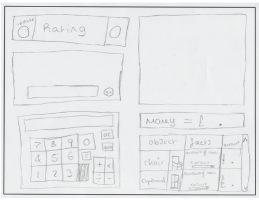
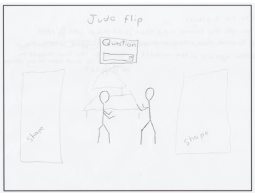
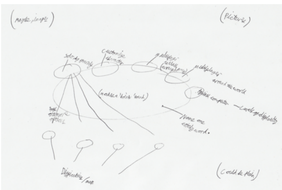
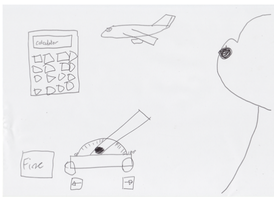
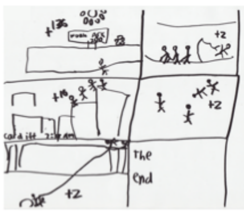
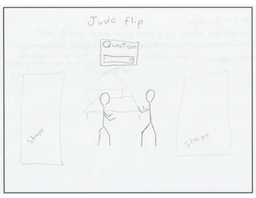
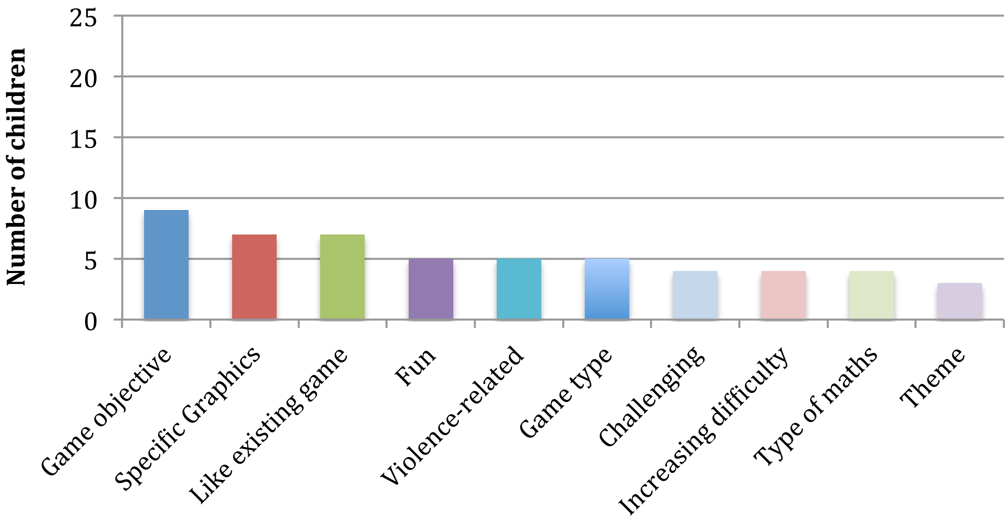
ASD group's top-rated 8 interface designs		TD group's top-rated 8 interface designs	
	Average rating: 7.3/10 Designed by **TD** participant		Average rating: 7.9/10 Designed by **ASD** participant
	Average rating: 7.2/10 Designed by **ASD** participant		Average rating: 7.9/10 Designed by **TD** participant
	Average rating: 7.1/10 Designed by **ASD** participant		Average rating: 7.7/10 Designed by **TD** participant
	Average rating: 7/10 Designing by **ASD** participant		Average rating: 7.6/10 Designed by **TD** participant
	Average rating: 7/10 Designed by **TD** participant		Average rating: 7.4/10 Designed by **TD** participant
	Average rating: 7/10 Designed by **TD** participant		Average rating: 7.3/10 Designed by **ASD** participant
	Average rating: 7/10 Designed by **ASD** participant		Average rating: 7.2/10 Designed by **ASD** participant
	Average rating: 6.9/10 Designed by **TD** participant		Average rating: 7.1/10 Designed by **ASD** participant

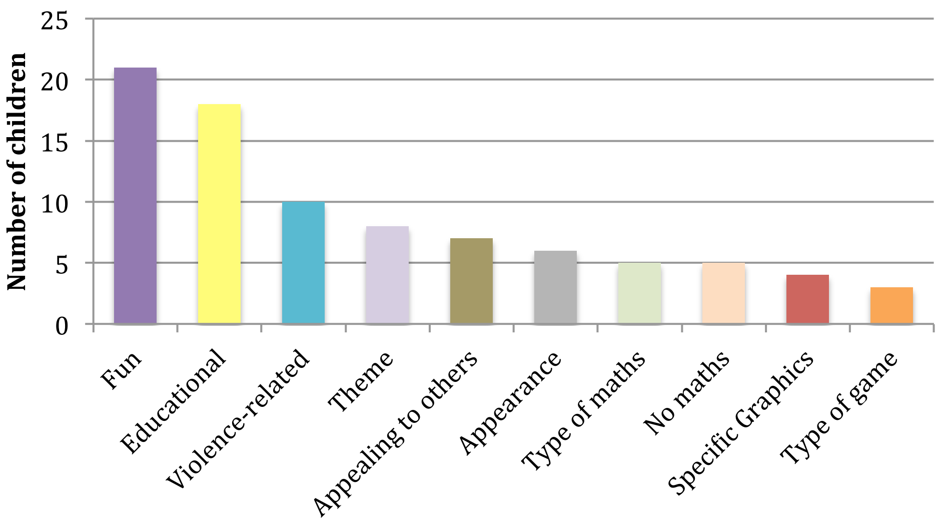
Table 4.3 – Top eight maths game interface designs for ASD and TD groups

Graph 4.1 and Graph 4.2 show a slight preference for the maths game designs produced by the TD children in terms of more receiving the higher ratings. However, looking at the top eight game designs with the highest average ratings from both the ASD and TD groups who took part in the evaluation activities each included four game designs produced by children with ASD and four game designs produced by TD children (see Table 4.3 on previous page). Four of these game designs (two ASD games and two TD games) appeared in the top eight of both groups, showing there is also some commonality in the preferences of children with ASD and TD children. Although there appears to be some similarities in the preferences, it is important to look at the reasons for these choices, which are discussed below. The results of this evaluation activity indicate the children with ASD do have the potential to generate ideas of a high quality, which are appealing to their peers with half of the maths game designs being given an average rating over 6/10.

Although there was some agreement in the favourite maths game designs between the ASD and TD groups, the reasons given for why they chose to give the designs a high rating varied significantly across the two groups. Graph 4.3 and Graph 4.4 show the most frequently stated reasons, given by three or more children from each group.



Graph 4.3 – Top 10 reasons given by ASD group for liking maths game designs



Graph 4.4 – Top 10 reasons given by TD group for liking maths game designs

The most popular reason for the TD group liking a game was because it looked fun, followed closely by if it would be good at helping you with maths or was particularly educational. In contrast there was a much wider spread of reasons for the ASD group liking particular games. The most popular reasons were because the child liked the objective of the game or specific elements within the game such as the player character as well as if it bore any similarities to existing games or TV programmes they were already familiar with. The actual maths was only mentioned by four children with ASD who liked the topic, as well as one child who liked it because the maths was easy and another child who liked a game because it did not include any maths at all. This indicates that children with ASD are rather more concerned with the game concept than if it will help them learn and many prefer to play something that has some kind of familiarity. This could be linked to the difficulty children with ASD have dealing with unknown and therefore unpredictable environments. It is also interesting to note that the TD children considered if other people would like the game and this formed part of their criteria for rating a game highly. Whereas no child with ASD said that the game appealing to other children influenced their high rating of a game, which could be explained by the egocentric characteristics of individuals with ASD as well as their difficulty understanding what others are thinking (Baron-Cohen, 2000b).

It is important to highlight the possibility of confounding influences within this study, based on the colourfulness of the design or the incorporation of the additional art materials available to those participants using the CI-based method. The cards shown to the non-participant children included a scanned copy of the original designs and therefore the few designs that did include additional materials appeared as a drawing. Additionally the participant children had the choice of whether to include colour within their design and many of them chose not to. It is possible that the colourfulness of some game designs could have made it more appealing to the non-participant children. However, within both groups only two designs incorporating colour were included in the top eight designs and colour was not mentioned as a specific reason within the top 10 reasons for liking a game, with the appearance of the games more generally only mentioned by six TD children. Therefore although these influences may have impacted the preferences of some children, it does not appear to have had a major impact on the overall results.

4.3 Participation Findings

This sections addresses **RQ2) To what degree can children with ASD participate in the design of technology and taking account of existing theories of autism, how do *existing design methods* need to be adapted to enable this participation?** Previous chapters have highlighted the limited number of opportunities that currently exist for children with disabilities to undertake a more active role both generally within society and more specifically during the technology design process. Guha et al. (2008) state that the level of this participation can depend both on the *type and degree of the children's disability*, which can impact the level of the children's skills, knowledge and abilities as well as the *availability and intensity of support*, which could include a one-to-one adult aide. It is also important to consider the impact on the child's participation that the power relations between the child and adult participants can have. Having a diagnosis of ASD can severely impact all of these factors, with a wide range in the level of skills, knowledge and abilities observed across the autism spectrum. Due to the difficulties children with ASD can have in these areas, the balance of power with adults is even more skewed than it is with TD children, as adults such as parents, carers and teachers are frequently required to make decisions on their behalf. Therefore even if some children with ASD do have the ability to potentially play a greater role within decision-making and become more active participants within the technology design process they may struggle to overcome the typical power relationships they have with adults on a daily basis. There could also be more behavioural issues requiring tighter control by adults, which could cause an even greater power imbalance. Study One aimed to begin the exploration of this issue by examining the children's ability to participate in typical design tasks, what role the adult needs to play to be able to support this participation and the extent to which they are able to engage within imaginative activities.

4.3.1 Role of the Adult

This section addresses the following sub-research question **RQ2a) What role do adults need to play to best enable the participation of children with ASD within the technology design process?** As has been established above, children with special needs such as those with ASD are more likely to require additional support to enable their participation within the technology design process. Adults frequently provide this support and therefore it is important to examine what their role within the process may entail. To address this research question the role of the adult facilitator was examined through the written observation notes, to determine when the facilitator was required to intervene during the session and what type of intervention they had to provide to enable the child to proceed with the task. These adult interventions were compared across the two design methods. It is important to note that the adult facilitator remained the same across both methods and therefore the intervention approach was applied as consistently as possible.

4.3.1.1 Adult Intervention during IDEAS method

During the IDEAS method one of the main interventions the adult facilitator had to undertake was to provide a number of *different prompts*. Some of the children with ASD struggled to remember the exact design task throughout the entire session and the facilitator had to prompt them to ensure they kept on track and were producing a design in-line with the original brief. The facilitator also prompted both groups of children to generate multiple ideas if they had only thought of one idea and also to prompt some of the children to expand upon their interface design if it did not completely fulfil the brief or they had not incorporated all of the ideas they had discussed verbally. The second role the facilitator had to undertake was to determine if any of the children needed *additional support* during the idea generation or design development activities and decide when a child needed a higher level of support in terms of the template they were provided, which was necessary in the case of six children with ASD. The facilitator also had to provide *reassurance*, *encouragement* and *praise* to many of the children from both groups if they were unsure if they were completing the activity correctly or was particularly worried about their drawing skills. Finally the facilitator had to *manage* overall the session, introduce each activity and inform the children when each activity had been completed.

4.3.1.2 Adult Intervention during CI-based method

During the CI-based method the adult facilitator also had to provide a *variety of prompts*. Some of the children with ASD were prompted every time they were required to make a verbal contribution and also to expand upon their interface design to ensure it incorporated all the required elements. Both children with ASD and TD children were prompted to generate multiple ideas if they had only generated one idea, to ensure they stayed on track and produced an appropriate final interface design. They were also prompted to elaborate on some of their verbal responses during the demonstration of the existing maths games, where some children only gave minimal input. Two of the TD children needed to be prompted to write down their ideas as they preferred to share them verbally. Again the facilitator had to provide *reassurance* and *encouragement* for children that were unsure about specific tasks or concerned about their drawing skills. Additionally for two children with ASD *additional guidance* of the content of the drawing was required to enable the children to begin their drawing. One child with ASD had dyslexia and so the facilitator provided *support for all writing-based activities*.

Finally the facilitator similarly had to *manage* the overall session, introducing each activity and supporting the transition to the next activity.

4.3.1.3 Comparison of Adult Intervention across methods

Across the two methods the facilitator had to use *prompts* for twice as many children during the CI-based method (12 children) than the IDEAS method (6 children), and had to prompt children with ASD more often than the TD children. This could be due to the additional structure incorporated within the IDEAS method that provided the children with more explicit guidance throughout the session. For instance, structure was provided for documenting multiple ideas and also the context for the explanation of the final interface design was provided through the cardboard mock-up computer. This could potentially enable the child to undertake the activities more independently. However, there was little difference in the amount of *reassurance* and *encouragement* the children required across the two methods. It was slightly increased for the TD children during the IDEAS method mainly to make reassurances about the children's drawing abilities or to confirm instructions for children that were lacking in confidence. The facilitator was only required to determine if the child required any additional support during the IDEAS method, but the use of the different templates provided the children a further opportunity to contribute what they were able, instead of it being all or nothing. Finally the facilitator was required to undertake a similar *management* role across both approaches, which is typical when involving children during the technology design process. Large et al. (2006, 2008) highlight the fact the adults will always be required to bring child participants to order when required and ensure that sufficient progress is being made.

4.3.1.4 Advance Session Planning

The management role described above requires the adult to determine in advance of the sessions what support strategies may be required. Therefore it is important to consider the role of advance session planning. Some of the children with ASD were unable to generate their own game ideas without additional support. This was true for more children with ASD within the IDEAS method, but the additional support incorporated into this approach allowed them to still make progress in the session. However, due to the relatively low numbers of children participating in this study it is difficult to generalise these results to say one method was more successful.

Of the children using the IDEAS method that required this additional support one boy was described by the teacher as "the most difficult child in the unit", one boy had a general dislike for computer games and another was a boy who was negatively impacted by losing the demonstration game (which would have also occurred had he been using the CI-based method). Therefore it is likely that these children would have had the same difficulties regardless of the method they used and the fact the IDEAS method had inbuilt support allowed these children to still make progress in the session. The IDEAS method had been planned in such a way to allow the facilitator with options to provide further support to the children allowing four out of the six children who had problems to successfully complete the session and still make a significant design contribution. The other two children still struggled to produce a fully formed idea due to their rigid thought processes preventing them from either moving on from thinking about their favourite game or a dislike for one of the example games, but they were still able to make a limited design contribution. This indicates a potential need for the adults to plan alternative activities, such as simply indicating preferences between existing design ideas, for children who are only able to make limited progress with generating their own ideas.

During the CI-based method when one of the children with ASD could not think of any ideas, the approach did not provide the facilitator with any alternative activities.

Therefore the child was simply asked to design his own version of the example game, not allowing him with any further opportunities to develop his own ideas. With the vast individual differences observed across the autism spectrum it is very difficult to develop one approach that is appropriate for all children and therefore this study has highlighted the need for flexibility and customisation within the design method in order to increase the chance of the child successfully undertaking a more active role within the technology design process. The other issue that arose during sessions using both methods and across both ASD and TD groups was that although some of the children really enjoyed the verbal discussions with the adult facilitator, other children were more naturally shy and wary of new people. This became a difficult barrier for some children to overcome and affected the quality of their contributions. Therefore in future sessions it would be important to plan time to build up this relationship and potentially also include adults that the children were already familiar with such as members of teaching staff from their school.

4.3.2 Engagement Findings

This section addresses the following sub-research question **RQ2b) What are the most effective techniques for engaging children with ASD as active participants within the technology design process?** It is important to establish if children with ASD are able to be intrinsically motivated by the design activities or if they require more extrinsic rewards in order to participate, as this will impact their resulting contribution to the activity. To address this research question a thematic analysis of the written notes from the sessions was undertaken to establish which factors impacted the children's engagement within, or disengagement from, the sessions. All instances of observed engagement/disengagement and the reasons for these behaviours were identified within the written notes. The reasons were then examined to establish common themes and were then grouped under these themes. The findings are discussed below and have been grouped by the key themes that arose from this analysis.

4.3.2.1 Visual Schedule (IDEAS only)

Within the IDEAS method the visual schedule was engaging for many of the children with ASD, the children demonstrated an interest in the schedule and two children specifically requested to tick off the last activity before they left the session. It also helped to engage one boy who was very distracted, but understood the session was not finished until he had checked off each activity.

4.3.2.2 Design Topic

The games-based design topic seemed to appeal to many of the children using the IDEAS and CI-based methods who played computer games in their spare time, with some children stating they wanted to be games designers. With the exception of one boy with ASD using the IDEAS method who said he did not enjoy playing games and so struggled slightly to engage with the task.

This general liking for games was further highlighted during the demonstration of the existing maths games in both methods. Within the IDEAS method some of the children with ASD and one TD child wanted to play the games themselves. Other children with ASD sat forward in their chair and paid greater attention to the games, with one boy saying the answers to the maths questions aloud within the game during the demonstration. One TD child also demonstrated curiosity about the games, asking the facilitator about different parts of the functionality. Within the CI-based method one boy with ASD became very excited about the games contributing to answering the maths questions during the demonstration and also starting to generate his own ideas before the demonstration had even finished.

However, the games decreased engagement in one boy with ASD using the IDEAS method, who was unable to answer the maths questions correctly, resulting in a negative impact on the remaining activities. In general there was a risk of the laptop on which the games were demonstrated on creating a distraction for the children, with one child with ASD wanting to look up other games to show the facilitator and other children trying to take over control so they could try out the example games themselves. Additionally, the writing of likes, dislikes and improvements on post-it notes during the CI-based method caused some disengagement amongst a few of the children from both groups who appeared not to like writing or were concerned about their writing ability.

4.3.2.3 Idea Generation

The idea generation activity within the IDEAS method seemed particularly engaging for some of the TD children, who spent a long time thinking about their ideas and did not struggle as much as some of the children with ASD did with this activity. Although more of the children with ASD appeared to enjoy verbally discussing their ideas with the facilitator as did one of the TD children, which may have been due to the opportunity of them having one-to-one attention from an adult for a significant period of time. There was an issue with a few of the children with ASD going off topic during the verbal discussion and therefore the adult needed to guide the discussion back to the task at hand to ensure the children did not become disengaged from the session.

In contrast to the IDEAS method there were three children with ASD that appeared engaged within the idea generation during the CI-based method spending time thinking about their ideas. However, there were also three children with ASD and four TD children who spent a minimal amount of time on this activity and a further three children with ASD who demonstrated difficulties with generating ideas. There was also one TD girl who became distracted during this activity. Again some of the children from both groups enjoyed having the opportunity to explain their ideas to the facilitator, but one boy with ASD did not enjoy speaking with new people and struggled with this part of the session. Two of the children with ASD and three TD children appeared to be engaged with producing their own interface designs and spent a long time on the activity.

4.3.2.4 Drawing and Art Materials

Two children with ASD and three TD children chose to use the pre-drawn images that were provided during the design development activity. One TD boy chose the different types of interface buttons to help him plan how the interface should look, which appeared to provide him with inspiration during the activity. Although these images were engaging for some of the children, they distracted one girl with ASD from her original idea resulting in a less coherent maths game because she wanted to include some unrelated images that she liked within the interface design. It is generally considered that drawing is an activity that appeals to children, however during the design development activity the requirement to draw out their game caused some concern amongst two children with ASD and one TD child who were worried about their drawing skills.

During the CI-based method a further two children with ASD demonstrated a clear preference for the drawing task over writing, but again there was one girl with ASD and one TD boy who were very nervous of drawing. Some of the children with ASD appeared excited by the additional art materials provided during this method, with one boy using these materials to demonstrate part of his idea. However, only two children with ASD and one TD child chose to incorporate these additional materials within their design. With the two children with ASD specifically choosing to include each one of the different materials provided. The materials also had the potential to be distracting, with one boy with ASD fiddling with the materials during the “bags of stuff” activity.

4.3.2.5 Cardboard Mock-up (IDEAS only)

The cardboard mock-up computer proved particularly successful in engaging the children with their interface designs, with some children mimicking interaction with their design as they would with a real computer, one boy with ASD standing up and 'presenting' his idea to the facilitator using it as a prompt. Several children in both ASD and TD groups were also prompted to add in more features to their design after viewing it in the cardboard mock-up.

4.3.2.6 External Factors

Finally there were a few minor external factors that influenced the child's engagement in the session including outside noise distracting one TD boy and one boy with ASD having a short attention span during an afternoon session, which from previous experience was a common occurrence with children with ASD later in the school day. Within the CI-based method external factors again occasionally affected engagement within the session, with one boy with ASD being distracted by noises outside the room.

The above findings highlight that the IDEAS only elements were generally quite successful in engaging the children within the design activities. However, other elements could be dependant on the child's individual characteristics. This indicates a need to provide different modes of idea expression to adapt to the child's preferences, to undertake the sessions in a distraction-free environment and also to potentially incorporate the child's own interests into the sessions if they are not directly linked to the design task.

4.4 Summary of Design Contribution and Participation Findings from Study One

Study One was focused on determining how to increase the comprehensibility of the PD environment and tailor it to the needs of children with ASD to enable them to successfully participate within and contribute to the technology design process. The study undertook an initial exploration of two research questions and the key findings from this chapter are summarised below under each of them.

4.4.1 Relevance to Research Questions

RQ1) Can children with ASD successfully generate and communicate *design ideas* and what implications do these ideas have in terms of designing educational technology for children with ASD?

There was a clear difference between the ASD and TD children's ability to produce design ideas. The fact that all of the TD children were able to complete the session successfully without additional support and a number of children with ASD were not indicates that there is a need for technology designers to take a different approach to involving children with ASD as active participants within the design process. It was clear that idea generation can be a particularly challenging activity for children with ASD and some form of additional support is needed in this area both as a guide for the process they need to follow and as an inspiration to provide a spark for the initial idea generation. There was also evidence within the CI-based method that children liked to express their ideas in a number of different ways and maybe the IDEAS method was too prescriptive in this respect. It is important to allow the children to express themselves in a way they feel most comfortable with and to ensure they are aware of all of the options available from the start as they may think there is only one "right" answer.

With respect to generating appropriate ideas the findings highlighted the difficulty some children, particularly those with ASD, have in simultaneously holding the two different elements of the design task in their mind, remembering they were designing something that was both a game and incorporated maths. Therefore there potentially needs to be additional support to help the participants retain this information. Also it appears that some children naturally operate at different levels of abstraction during the idea generation process, considering the idea at a much higher level and not focusing on the specific details. This is not something that is considered typical of children with ASD, who are thought to focus more on the finer details of things (Happé and Frith, 2006). However, it highlights what a vast spectrum ASD encompasses and that all activities should be able to be tailored to the individual participant's needs and allow them to contribute ideas at various levels of abstraction. Many children with ASD have difficulty coping with failure, which was highlighted by the boy whose participation in the session was negatively impacted after he had difficulties with one of the example maths games. Therefore it is important to ensure there is no opportunity for a child to 'fail' within the session (e.g. by emphasising there is no correct answer to activities).

Furthermore to consider the impact that early activities may have later on in the session as children with ASD can find it difficult to 'move on' from certain experiences, both positive and negative. Finally although some children with ASD were unable to generate original ideas of their own, in general demonstrating examples of existing technology did not mean that children with ASD were unable to generate their own ideas, which were different to or extended these examples. This supports the notion that children with ASD are able to generate reality-based creative ideas within a contextually meaningful task i.e. a new maths computer game (Craig and Baron-Cohen, 1999, Low et al., 2009), but that some children with ASD may have a reduced ability to generate novel ideas. Therefore providing a template-based structure can help provide a starting point to the idea generation process.

The analysis of the design contribution findings related to the final maths game interface designs produced during the design sessions indicated a number of potential implications for further developing a set of design principles for educational technology aimed at children with ASD. However, it is important to treat these implications with caution as the children's ability to generate and communicate design ideas, both verbally and visually, may have impacted the final design outputs. Therefore further work is required before any firm conclusions can be made on specific design principles, by providing the children with additional support in the generation, communication and documentation of their ideas. This area of research will be explored further within Study Two and Three, and the set of design principles further revised based on the findings from these studies.

The analysis of the results from the non-participant evaluation activity initially suggested little difference in the preferences of the ASD and TD groups. With similar average ratings given to designs produced by children with ASD and TD children as well as some similarities in the specific games that were rated highest. However, considering the reasons behind these preferences revealed clear differences in the reasons for liking a game design, with a higher amount of variability in the specific reasons given within the ASD group. The reasons given by the children within the ASD group were more focused on specific elements of the game, whereas the TD children had a higher tendency to consider the experience/appearance of the overall game and also how well it achieved the goal of helping the player to learn/practice maths. This difference could be explained by the WCC theory (Happé and Frith, 2006) and the inclination for children with ASD to focus on the finer details of things, experiencing difficulties considering the game as a whole and generalising their reasons to apply to the overall game. Similarly it could also be explained by the E-S theory (Baron-Cohen, 2009), which suggests the children could be trying to understand the game by focusing on the different elements such as the objective or the characters.

Furthermore the fact that no child with ASD mentioned whether the game would appeal to other children, in direct contrast to many of the TD children, could be linked to ToM/E-S theories (Baron-Cohen, 2000b, Baron-Cohen, 2009) and the difficulties of children with ASD in recognising and interpreting the thoughts of others. This suggests they may not know which games would appeal to others or believe that all games that appealed to them would also appeal to others. Lastly, children within both groups indicated a liking for violence-related games, which could conflict with incorporating age-appropriate content and also for ensuring educational games are suitable to be played in school. Therefore this is an area where compromises between appropriateness and appeal may need to be made.

RQ2) To what degree can children with ASD participate in the design of technology and taking account of existing theories of autism, how do *existing design methods* need to be adapted to enable this participation?

The findings across both methods indicate the importance of the adult undertaking a number of different roles, which include providing prompts, reassurance and encouragement as well as managing the overall session. Although it appears that the use of prompts is necessary, these do not help to reinforce a more equal power balance between the adults and children. Therefore by using other methods of providing these prompts and guidance on the activities (such as the use of the paper-based templates and the visual schedule within the IDEAS method), this may help to provide additional ways to reinforce the activity and reduces the number of verbal prompts the adult has to provide. The adult also needed to take on a caring role to provide reassurance and ensure the well being of the children. As well as providing explicit support for this, if the adult undertakes the activity with the child, the child may feel more comfortable that they are making good progress instead of being unsure that they are following the right path when working individually.

There were a number of elements of the sessions that appeared to be engaging for the children, encouraging greater participation. The task of designing a game seemed to appeal to both ASD and TD groups, with many playing games in their spare time. It is important that the task has some form of appeal to increase the initial engagement and interest in the session. The demonstration of existing maths games captured the children's attention, with games containing greater animation and sounds most appealing. It also provided a concrete representation of the design topic, taking the focus away from the child for part of the session, potentially helping more nervous children and also those children with ASD that struggle with direct eye contact. The findings highlighted the fact that the children had different preferences in terms of expressing their ideas, most commonly by drawing and discussing verbally. Therefore it is important to provide the children with multiple channels for expressing their ideas and allow them to choose the one they are most comfortable with. The cardboard mock-up computer used in the IDEAS method also showed that the way the children's final ideas are presented is important and allowing them to see their ideas directly transferred onto the computer may increase engagement further.

To further support the active participation of the children throughout the sessions, it is important that the issues raised from this study are addressed. There needs to be time to build up relationships with children to help them feel more comfortable interacting with the adults. It could be beneficial to include at least one adult with which the children are familiar. Also to have an even number of adults and children, so the adult can still provide one-to-one support if required but the children do not feel outnumbered. There should be clear rules to guide the session to ensure the children know what is expected of them and potentially distracting equipment and materials, such as laptops and art supplies should only be accessible when they are being used for a specific activities. The sessions should take place in a quiet, distraction-free environment wherever possible, although this can be difficult when undertaking sessions within a school environment. Across both methods it was clear that many children, but particularly those from the ASD group, often had very individual needs and preferences that could affect their engagement and how the sessions needs to be managed. Therefore it is important to plan in a flexible way, providing alternative options in each activity and also allow "on the fly" tailoring of the session to ensure the continued successful participation of the child.

4.4.2 Summary

One of the key findings from this chapter is that children with ASD may potentially need additional support to allow them to participate within typical PD activities. The form of this support can vary between children, but it needs to take into account the children's preferred mode of idea expression and level of idea abstraction, as well as potential difficulties related to concerns about failure, initial idea inspiration and the consideration of two related elements of a design concept simultaneously. The findings discussed in this chapter also pointed to the need for an adult to undertake a number of different roles within the design process, including providing prompts and guidance to the child. Furthermore the choice of task and inclusion of computer-based demonstrations appeared to be important mechanisms of engaging the children within the session.

The above findings have a number of implications in terms of refining the IDEAS method further to allow it to be used successfully with a design team that includes children with ASD. These implications include the need to incorporate time to build up relationships between the child and adult participants, the provision of one-to-one support for children that require it, the minimising of potential distractions, as well as ensuring the method is flexible enough to allow it to be adapted to the individual needs and preferences of the children. These implications are discussed in more depth in the following chapter along with a description of the refined version of the IDEAS method used in Study Two.

Chapter 5 Study Two: Collaborative Design Contributions

5.1 Introduction to Study Two

Study Two examined the ability of children with ASD to participate within a design team and undertake design tasks in collaboration with other design team members, both children and adults. This chapter builds on the *design contribution* findings from Study One with respect to **RQ1) Can children with ASD successfully generate and communicate *design ideas* and what implications do these ideas have in terms of designing educational technology for children with ASD?** Although Study One established the potential ability of children with ASD to generate and communicate design ideas individually (with appropriate support) PD involves undertaking these activities as part of a design team of different stakeholders. Therefore this research question is explored in relation to the design contributions made from within a collaborative design environment, which involved working with other design team members.

To explore the *design contributions* made by the child participants within this study, the outputs from the design sessions were analysed firstly to determine the children's support needs in generating and documenting their design ideas. Secondly, the outputs were also analysed to establish their ability to produce design ideas that were both appropriate and exhibited some degree of originality. These design outputs were also evaluated to determine their wider appeal both within the design teams and the children's wider peer groups, as well as any further implications for children's technology design. Prior to the presentation of the findings from this study the modifications made to the IDEAS method based on the outcome of Study One are discussed and then followed by a description of the study methodology.

5.2 Refining the IDEAS method

The refined version of the IDEAS method is described below and presented diagrammatically within Fig. 5.1, with the specific refinements highlighted in green. It continues to use the TEACCH Structured Teaching approach as a framework. These refinements are based on the findings from Study One (coded S1) and also from the review of the ASD and collaboration literature presented in Chapter Three (coded CL). This version of IDEAS was developed for use over a series of six PD sessions with a design team incorporating three children with ASD, two university researchers and one teaching staff member from the children's school. The key changes are described in detail below.

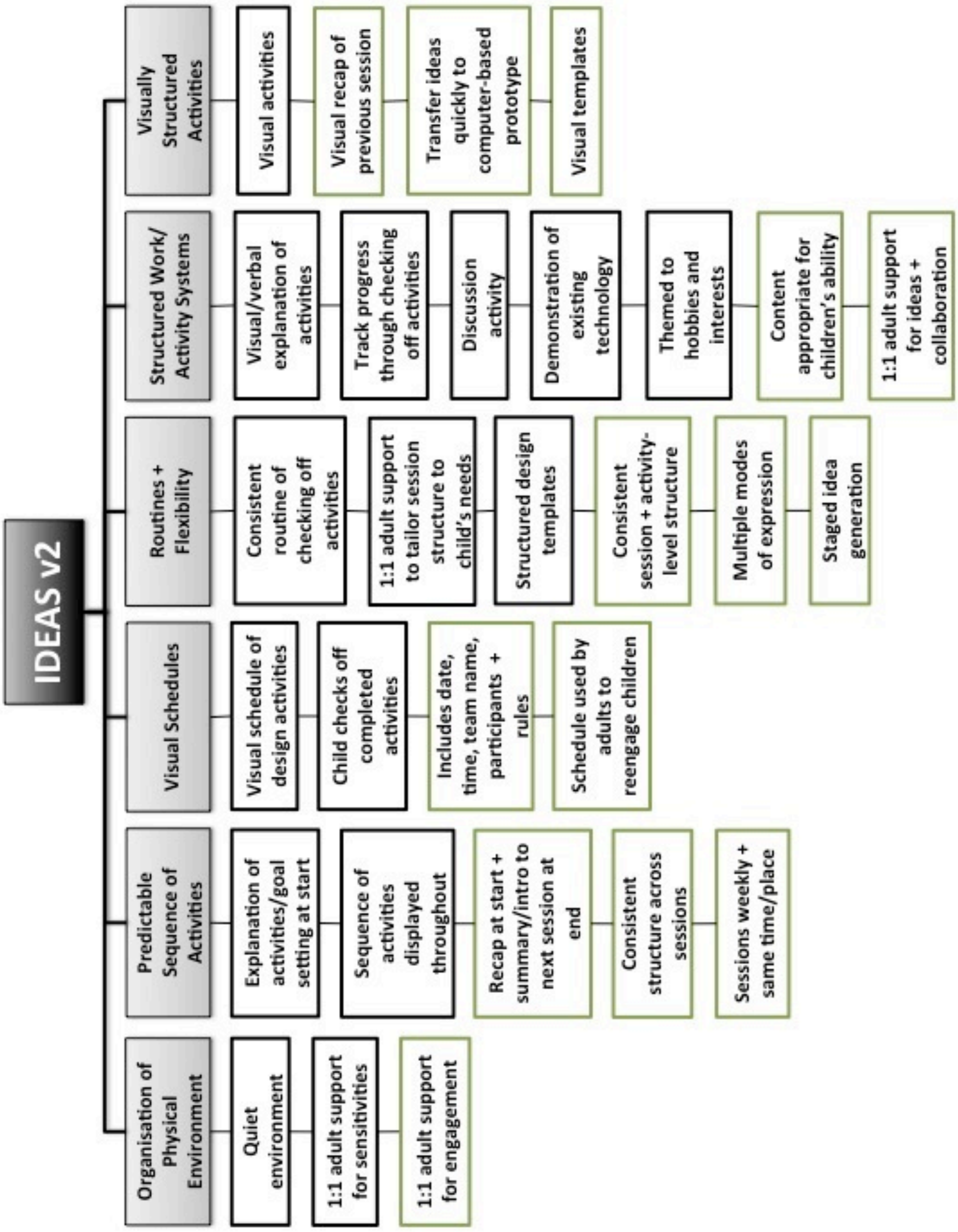


Figure 5.1 – Refined version of IDEAS method used in Study Two (refinements highlighted in green)

1. *Organisation of the Physical Environment* – one-to-one adult support is available at all times (CL), enabling the tailoring of the environment to individual sensitivities and preferences of the children where necessary. Also to provide support for individual children if they become distracted or disengaged.
2. *Predictable Sequence of Activities* – there is a recap of the previous session at the start of each session to help the children remember the stage they are at in the design process. The session structure is kept consistent throughout (S1), each session beginning with a recap, then an explanation of the activities for the session and finally a summary at the end, which includes a description of what will happen the next week. Where possible the session is

undertaken at the same time and same place every week to help create a predictable familiar environment (CL).

3. *Visual Schedules* – the visual schedule has been redeveloped for the team to use as a whole (S1). It is now displayed on a whiteboard and includes the additional information needed for the change in setup such as session date and number (as there are now multiple sessions), participants taking part (as there are now multiple participants) and session rules to help provide guidance for the collaboration (see Fig. 5.2). This visual schedule keeps a record of which activities have been completed, with one child assigned the responsibility for checking off the activities as they are completed. This is supported through the use of the visual schedule to bring the child back to the activity and to visually highlight closure of one activity and the progression to the next activity (S1).

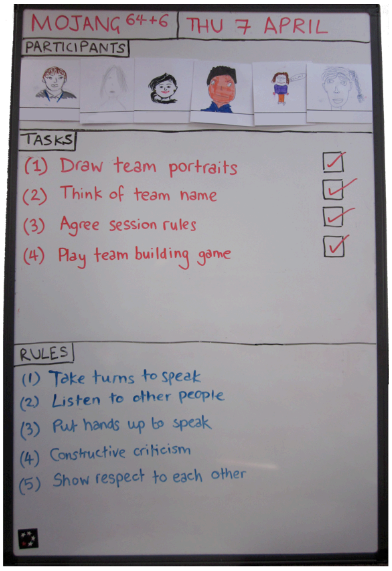


Figure 5.2 – Whiteboard-based visual schedule

4. *Routines and Flexibility* – the consistent high-level session structure helps the session to become a familiar routine to the children (S1). The idea generation and elaboration activities also follow a consistent routine, focusing on individual elements of the design topic in the same order during each session. The staging of the idea generation process can be tailored, with the addition of more stages if the children are struggling to combine their ideas together (CL). Multiple ways of expressing ideas are offered including drawing or writing on templates as well as the option to explain verbally to an adult who can then annotate these ideas on the template (S1).
5. *Structured Work/Activity Systems* – the design task needs to be carefully devised to appeal to individual interests of the children. These interests are discovered during the initial session or by talking to the children's teachers, to ensure the task is appealing, interesting and stimulating for the children (CL). It is also important to be aware of the children's ability prior to the session, so only educational content at the appropriate level is incorporated. The adults provide a range of one-to-one support to aid idea generation, providing praise and encouragement for any ideas generated, and offering potential design suggestions to help inspire initial idea generation (S1,CL). They also facilitate interaction with other team members as well as directly addressing quieter team members (S1,CL).

6. *Visually Structured Activities* – at the beginning of each session the recap of what happened during the previous session is presented visually. The design task is also represented visually by demonstrating multiple existing examples (S1,CL). In order to make the later design activities more concrete and meaningful the team's ideas are transferred onto the computer as quickly as possible. Later sessions then incorporate both paper and computer-based versions to help the children see the connection between their ideas and what they were actually designing in a visual way (S1). The children are all provided with visual templates on which to begin generating their ideas to help provide inspiration for this (S1).

5.3 Study Two Methodology

5.3.1 Participants

Study Two involved four separate design teams, two teams incorporating three children with HFA/AS aged 12-13 years and two teams incorporating three TD children aged 11-13 years (see Table 5.1 for an overview of the child participants). The children with ASD were diagnosed with HFA/AS by a clinician using the DSM-IV criteria and as a result of this diagnosis attended one of two participating specialist ASD schools (ASD School 2 and 3). The TD children attended one of two mainstream secondary schools and were incorporated as a comparison group for this study (Mainstream School 1 and 2). All of the children within each design team attended the same school. The difference between the ages of the ASD and TD children was not statistically significant (t_{11}=0.7, p>0.05). The teams were matched so that there was one ASD/TD team with three boys, and one ASD/TD team with two boys and one girl.

Team Name	Child Participant 1	Child Participant 2	Child Participant 3
ASD Team 1	M1 aged 12, VIQ=102	M2 aged 13, VIQ=88	F1 aged 12, VIQ=104
ASD Team 2	M3 aged 13, VIQ=89	M4 aged 13, VIQ=89	M5 aged 13, VIQ=98
TD Team 1	M6 aged 11, VIQ=102	M7 aged 13, VIQ=88	F2 aged 13, VIQ=102
TD Team 2	M8 aged 13, VIQ=91	M9 aged 13, VIQ=96	M10 aged 12, VIQ=98

Table 5.1 - Overview of Child Participants in Study Two

The teams were also matched on verbal IQ, with the verbal IQ of the children with ASD ranging from 88-104 and the TD children ranging from 88-103. The difference between the verbal IQs of the ASD and TD children was not statistically significant (t_{11}=0.7, p>0.05). Verbal IQ was measured to ensure that the children all had a sufficient level of verbal ability to enable them to understand the session instructions, communicate their design ideas and ask for help if they experienced any difficulties. The Wechsler Intelligence Scale for Children (WISC), which is appropriate for use with children aged 6-16 years, was used to measure the children's verbal ability. The WISC was undertaken on a one-to-one basis with all of the children with ASD by a trained researcher, and was undertaken under 'exam conditions' during class with the TD children, with an adult available to provide support where necessary. The verbal IQ is calculated based on the children's current age, which enables the results to be directly comparable across age groups.

Each team also included two adult researchers, one with a background in computer science and the other with a background in autism, as well as a teaching staff member from the children's school. It was important that there were enough adults on the team to provide one-to-one support for individual children, as well as to provide mediation for social interaction and to enforce social rules such as turn taking and listening to others where necessary. The children with ASD all knew each other well due to the smaller numbers of pupils in each year group at the specialist ASD schools. However, the TD children were chosen solely based on their match to the participants with ASD and did not necessarily know each other as well. The children in TD Team 1 knew each other but were not in the same friendship group. Two of the boys in TD Team 2 were friends, but they did not know the third boy who was in a different school year. The teaching staff member within both of the ASD teams was a teaching assistant and regularly provided support for each of the children with ASD during their classes. Within TD Team 1 the teaching staff member was a learning mentor, whose job was to provide pastoral care for the pupils within her community, however none of the participant children were in that community and so she did not have an existing relationship with them. Within TD Team 2 the teaching staff member was a maths teacher and had not previously taught any of the participant children, so did not have an existing relationship with them.

The teams undertook the sessions within a separate room away from their classroom; this was always the same room except for TD Team 2, which changed each week due to high demand for rooms at the school. The children in ASD Team 1 participated in the sessions instead of doing their maths lesson and the children in ASD Team 2 participated as part of their citizenship lessons. The TD children missed a number of different lessons due to a variability in timetabling and a requirement for them to not miss too many of the same lesson. Fig. 5.3 shows the typical setup for each of the teams.

ASD Team 1

ASD Team 2

TD Team 1

TD Team 2

Figure 5.3 – Study Two setup for each of the teams

5.3.2 Data Collection Methods

Each of the design sessions were videotaped, after providing detailed information about the use and storage of the videos to the participating schools and gaining appropriate consents for this. Parents of the child participants were also sent letters explaining the project aims, and their child's role within the project, ensuring they were aware that their child could be withdrawn at any point if necessary.

Prior to the study the 13-point ethics checklist required by the University of Bath Computer Science Department when involving participants in research was completed and can be found in Appendix B. The wider project that this work formed part of also met the British Psychological Society ethical code and was approved by the Department of Psychology and University of Bath ethics committees.

5.3.3 Procedure

During Study Two each team undertook a series of six design sessions on a weekly basis, with each session lasting approximately one hour and being conducted at the children's school in a quiet room separate from their classrooms. The sessions all followed the refined version of the IDEAS method, described earlier, which had been modified based on the findings from Study One and also to enable it to be used with a design team over multiple sessions. A whiteboard-based visual schedule was used to display the activities for each session, with one child from the design team assigned (or volunteered for) the role of checking off the activities as they were completed. The visual schedule also displayed additional information about the session, including the date as well as the team name and rules agreed upon during the first session.

Each session began with a visual recap of the previous session (except for session one) to remind the children of what they had already achieved. As in Study One all of the teams were set the task of designing a maths game for the children's peers, however this time the task was more tightly defined. The teams were shown an existing maths game and asked to focus on improving the feedback for getting the answer to the maths question correct and incorrect as well as developing a reward scheme for winning the game. The children were rewarded for their participation by being allowed five minutes at the end of each session to play a game of their choice on an iPad. The children were only allowed to choose from the multiplayer games, which allowed them to interact with the iPad simultaneously to further encourage collaboration amongst team members.

Below is a description of the six design sessions each of the design teams in this study undertook:

- **Session 1** (Team Building): this session involved a series of introductory activities to help structure social interaction. The teams firstly undertook an 'ice-breaker' activity, where they were tasked with drawing team portraits. Each team member randomly picked a name of a fellow team member (or themselves) and then had to draw a representation of that person, which could later be displayed on the whiteboard-based visual schedule. As part of the activity the other team members had to guess who they had drawn. The second activity was to generate and agree upon a name for their team. They then also agreed upon a set of rules that would be important for everyone to abide by during the sessions and which were also displayed on the visual schedule. Finally as a team-building activity the children (supported by the adults) had to work together to build a LEGO® board game. Each child was assigned a different role, based on the LEGO® therapy intervention for children with ASD (Legoff and Sherman, 2006), either director, supplier or builder. This meant they had to work together in order to successfully build the game. The team then played the game together after they had completed the build.
- **Session 2** (Context Setting): this session involved a discussion of the children's prior experiences related to the design task. They were asked about how they received positive and negative feedback, and were rewarded, both in school and when playing computer games. The teams were then shown two existing maths games, Bloons Tower Defence and Sky Solver, which were demonstrated on a laptop computer (see Fig. 5.4). Bloons Tower Defence is a one-player game and requires the player to stop the balloons from escaping by buying things to shoot and pop them. Sky Solver is a one-player game and requires the player to shoot the planes with the correct

answer to the maths question displayed at the top of the screen. The team members were also able to play two existing games on an iPad, Math Bingo and Marble Mixer (see Fig. 5.5). Math Bingo is a one-player game and involves answers five maths questions within a row on a grid in order to get 'Bingo'. Marble Mixer is a two to four-player game and involves rolling the most marbles into the monster's mouth in the centre of the screen. After each of the games the teams were asked to discuss how the game gave feedback and how it rewarded you, as well as if they thought the game did this well or not.

Figure 5.4 - Two demonstration games on laptop - Bloons Tower Defence and Sky Solver

Figure 5.5 - Two demonstration games on iPad - Math Bingo and Marble Mixer

- **Session 3** (Idea Generation): this session involved the generation of initial individual design ideas. Firstly each team member was given a paper-based template (see Fig. 5.6), incorporating a screenshot of one of the existing maths games demonstrated during session two. Each team member was asked to draw or write his or her ideas on this template for how the game could provide improved positive feedback for getting the answer to the maths question correct. The team members then took it in turns to verbally share their ideas with the rest of the group. The same process was followed for generating ideas for negative feedback and incorporating a reward scheme for winning the game. Each child was then paired with an adult and each pair assigned responsibility for combining together the team's ideas for one of the three game elements (positive feedback, negative feedback and reward scheme). This involved examining each of the individual templates for their assigned game element, discussing which ideas were the best, and then drawing or writing these ideas on a larger paper-based template.

Figure 5.6 – Example individual paper-based idea template for positive feedback

- **Session 4** (Design Development): prior to this session one of the researchers transferred each of the three group ideas from session three into a computer-based interface design using Adobe Photoshop. This session began with the computer-based interface design representing the positive feedback ideas being shown to the design team on a laptop computer. The interface design was also printed out on a large sheet of paper and the team were asked to discuss how the different elements of the game could be animated and document these ideas on the paper-based version of the game. The same process was then followed for the negative feedback interface design and also for the reward scheme interface design.
- **Session 5** (Design Refinement): prior to this session one of the researchers transferred the game ideas into three Adobe Flash-based non-interactive videos representing the three different game elements. This session began with the video representing the positive feedback in the game being shown to the design team on a laptop computer. A paper-based storyboard of this video (e.g. Fig. 5.7) was also provided and the team were asked to discuss how this video could be improved and document these ideas on the paper-based storyboard. The same process was then followed for the negative feedback and reward scheme videos.

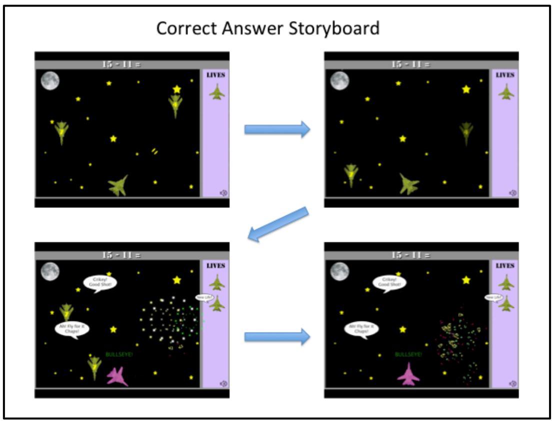


Figure 5.7 – Example paper-based storyboard template

- **Session 6** (Evaluation and Reflection): prior to this session one of the researchers made the changes to the Flash-based game videos (that were agreed during session five). This session began with the demonstration of each of the final game prototype videos to the team. The child participants were then asked to complete a survey to find out their opinions of the final game ideas (see Appendix C). This survey incorporated a Smileyometer Likert scale (Read and MacFarlane, 2006), which is described in more detail in section 5.4.3.4, as well as basic multiple choice questions to make it as easy as possible for the children to complete. If any child experienced difficulties with reading the questions an adult was able to read out the questions for them. The children were then given a set of paper-based templates, each representing one of the previous sessions, and a set of images representing the different activities they had undertaken (e.g. Fig. 5.8). They were asked to produce a display of their work from the previous sessions by sticking the images to the correct template and writing down their likes/dislikes of the different activities. Finally the team presented this work to a senior teacher/head teacher from their school and described what they had achieved over the past six sessions. All of the children were given certificates and small gifts at the end of the last session to thank them for participating in the study.

After the last session the teacher/teaching assistant completed a survey to share her opinions of the design process and if she thought the children benefited from participating (see Appendix C). The children also completed a second survey to find out their opinions of participating in the sessions (see Appendix C).

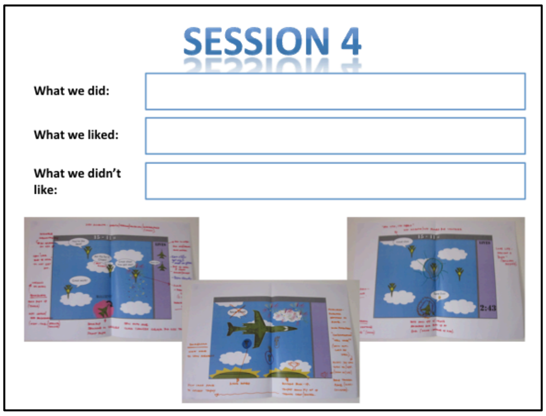


Figure 5.8 – Example template for Session 4 and corresponding images representing session activities

5.3.4 Outputs and Analysis

In order to address **RQ1** the outputs from Study Two were analysed (see Table 5.2). The analysis of each output has been guided by a series of sub-research questions, which are noted within Table 5.2 and discussed in further detail below.

Output	**Sub-Research Question**
Completed individual and team idea templates	RQ1a, RQ1b
Digital videos of Sessions Three, Four and Five	RQ1a
Final prototype game videos	RQ1c
Completed Final Game survey from participant children	RQ1c
Non-participant children's ratings/ranking of final game prototypes	RQ1d

Table 5.2 – Outputs of Study Two and related sub-research questions

RQ1a) Do children with ASD require any form of support in order to generate and/or communicate their design ideas?
To address this sub-research question the completed templates containing the teams' individual and collective design ideas were analysed to establish how the children documented their ideas and what support they required to do this. Additionally the videos from sessions three, four and five, when the design ideas were generated and developed were analysed to determine the type and level of support the children required during the idea generation process.

RQ1b) Are children with ASD able to generate design ideas, which are both appropriate and demonstrate some level of originality?
To address this sub-research question the design outputs from the idea generation and development activities during sessions three to five were analysed to establish the extent of the appropriateness and originality of the children's ideas. An existing categorisation of feedback and rewards from the computer game literature was used to establish the appropriateness. The children's ideas were also compared against the feedback/reward mechanisms incorporated within the initial game (provided as a starting point for the design task) to determine their novelty in relation to the original mechanisms.

RQ1c) What specific implications do these design ideas have for designing educational technology aimed at an ASD population?
To address this sub-research question the final prototype game videos produced by each design team where analysed alongside the participant children's opinions on the final prototype games collected within the Final Game survey undertaken during the last design session. This was done to establish any visual design, feedback and guidance, and motivation and engagement preferences and based on these preferences what the resulting implications for educational technology design may be.

RQ1d) Do these design ideas appeal to other children within the ASD population?
To address this sub-research question the final prototype game videos were shown to a group of children with ASD and a group of TD children (all of whom had not participated in the study) to establish their opinions of each team's game design. The results of this evaluation activity were analysed to determine which game designs were most appealing to each peer group.

The findings from this analysis are described in more detail below.

5.4 Study Two Design Contribution Findings

5.4.1 Support for Idea Generation and Communication

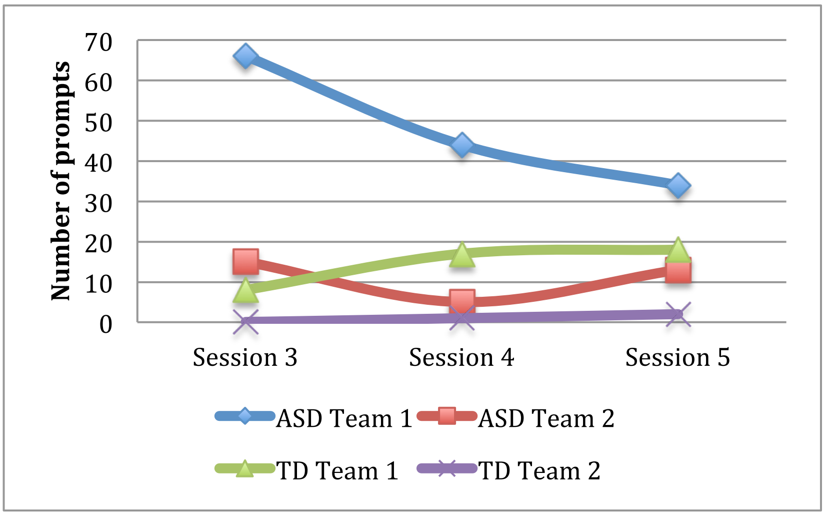
This section addresses the sub-research question **RQ1a) Do children with ASD require any form of support in order to generate and/or communicate their design ideas?** In the previous study it was established that children with ASD did have the potential ability to generate and communicate design ideas. However, this was when working individually and as they only participated in a one-off session there was also little opportunity to progress these ideas. It was found that some children with ASD struggled with this task and required additional support in the form of design templates and adult prompting. This ability was further explored within Study Two, with the focus on their ability to both generate design ideas when working as part of a design team and also to then build on these ideas over a series of design sessions. The completed templates containing the teams' individual and collective design ideas were analysed to determine how the children documented their ideas and what additional support was required during this process. These design ideas were generated and documented during sessions three, four and five. The analysis revealed differences between all of the teams in the approaches to i) generating ideas and ii) documenting those ideas, and the role the adult played within this process.

5.4.1.1 Support for Generating Ideas

The adults provided support for the actual idea generation through explicit prompting of individual children and also by using motivational language such as praise and encouragement. The transcripts from session three, four and five were analysed by coding any utterance where an adult directly prompted a child to contribute an idea, e.g. *"What colour would you like M2?"* and also when they praised a child's idea, e.g. *"Well done…that's a good one"* or provided more general encouragement to the entire team, e.g. *"Well done guys, you're working really well as a team"*.

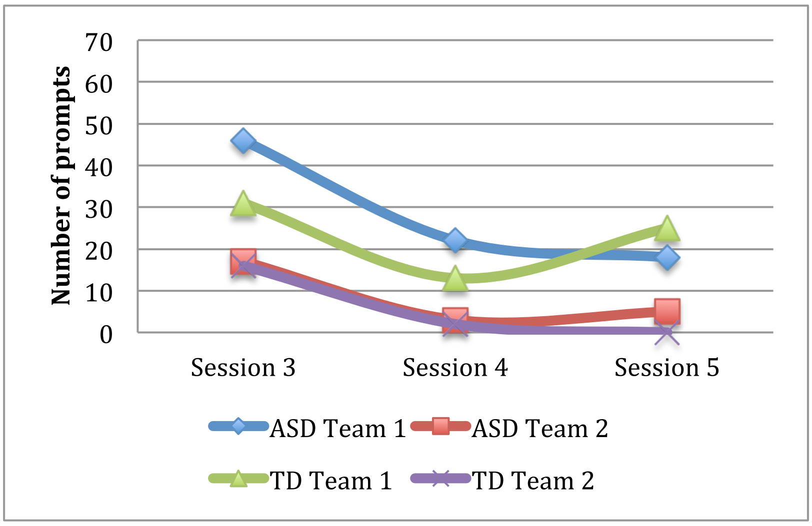
Graph 5.1 shows that the children in ASD team 1 required many more *direct prompts* to contribute ideas. However, the level of prompting dropped substantially from session three to session five to just over half the level that was initially required. The level of prompting was much lower within ASD team 2 as they had many ideas and were confident in sharing these ideas verbally from the outset. There was a drop in the level of prompting during session four, which could potentially be due to the absence of M5 from the session, who typically required more prompting that the other children. Although M5 did have his own ideas the other two boys were more dominant during the sessions and therefore the adults had to prompt M5 to speak up, allowing him the opportunity to share his ideas. This may be linked to the personalities of the children rather than their ASD diagnosis, as this could also be true of TD children.

The need to prompt the children in TD team 1 increased when the children were reluctant to try and improve on the ideas they had in later sessions, wanting instead to reach their reward time more quickly. In contrast TD team 2 required little direct prompting to contribute ideas. This indicates a potential difference in the use of prompts between the ASD and TD teams. Prompting was required within the ASD teams to encourage the children to generate and share ideas because of low confidence or difficulty with the task, whereas within TD team 1 prompting was instead required to return to task because of an impatience to reach a reward.



Graph 5.1 - Frequency of adult prompting for contributions during sessions 3 – 5

Graph 5.2 illustrates the level of *motivational statements* used by the adults in the team. It again shows that this started at a higher level in ASD team 1 to encourage them to share their ideas and praise them for any ideas they were able to generate to help build up their confidence. In general across all teams the level of motivational support was highest during the initial idea generation and lessened during the later sessions as the children became familiar with the task and increased in confidence. However, this again increased in session five with TD team 1 to encourage them to stay engaged in the task when they became distracted by each other, other children outside of the classroom and also again the prospect of reaching their reward time more quickly. This indicates a change in the children's motivation between the early and later designs sessions, with an increase in familiarity and confidence helping to increase self-motivation. However, this increased familiarity could potentially have resulted in a decrease in interest in the task if the sessions felt repetitive to any of the children. This may explain the increased disengagement within TD team 1 during the later sessions, although it is difficult to establish precisely why this happened as it could also be influenced by a number of external factors.



Graph 5.2 - Frequency of adult motivational statements during sessions 3 - 5

5.4.1.2 Support for Documenting Ideas

Within ASD team 1 the children both wrote and drew their individual ideas on the templates during session three, writing spoken elements of their ideas in speech bubbles and also writing basic written labels to explain other elements of their drawing. Two of the children incorporated further written explanation at the bottom of their paper templates for some of their ideas. During the 'Big Idea' activity in session three the children and adults *worked together to combine the ideas* and for each big idea both the child and adult responsible documented these ideas by writing and drawing on the template. During session four and five one of the adult researchers *documented all of the team's ideas on the template*. However, the children themselves added to this by drawing out any images, which they wanted to be incorporated or modified, but were unable to explain verbally.

Within ASD team 2 the adults were required to support two of the children during the individual idea generation activity. One boy had dyslexia and wanted to express his ideas through writing but was unable to do so, so he verbally explained his ideas to one of the adults who *wrote them on the template* for him. Another boy had a sensitivity issue related to touching paper and therefore another adult *documented his ideas on the template* for him so he did not have to touch the paper. The other boy wrote his ideas on the template himself, these were short written explanations, which he then expanded upon verbally when he shared his ideas with the rest of the team. During the 'Big Idea' activity the adult working with each child to combine the ideas *wrote or drew the ideas* *on the template*, as two of the boys required the extra support and the other boy preferred to explain his ideas verbally. During session four and five one of the researchers *documented all of the team's ideas on the templates*, with the children only describing their ideas verbally.

Within the TD teams all of the children used a combination of writing and drawing to document their individual ideas on the templates. The children in TD team 1 included some more basic written labelling of elements, whereas the children in TD team 2 incorporated much more detailed written labels and further explanations. During the 'Big Idea' activity the adults and children in TD team 1 *wrote and drew the combined ideas together* on the templates, whereas the children in TD team 2 preferred to write and draw the combined ideas themselves with the adults *providing verbal input*. In contrast during session four and five one of the researchers *documented all of the team's ideas on the templates*, with the children only describing their ideas verbally.

These findings highlight that some of the children with ASD had issues with writing and drawing ideas and it was therefore important that the adult support for this activity was provided. Within the other teams there were some general concerns about drawing skill and spelling ability expressed that made some children hesitant to express themselves directly on paper. However, during the earlier sessions some of the children with ASD were less confident with expressing their ideas verbally and therefore it was necessary that the opportunity of drawing/writing their ideas was provided. The differences between the teams in their preferred methods of expression again emphasise the need to have multiple options available. This is of particular importance within the ASD teams who could have more difficulties with certain methods of communication, motor skills, reading/writing ability and other sensory issues, which can be very specific to the individual children.

5.4.2 Appropriateness and Originality of Ideas

This section addresses the sub-research question **RQ1b) Are children with ASD able to generate design ideas, which are both appropriate and demonstrate some level of originality?** The importance of this research question was established during the previous chapter due to the potential implications that difficulties in these areas can have on the value of the contribution children with ASD could make to the technology design process. Therefore it is necessary to additionally establish the ability of children with ASD to generate appropriate and original ideas within a collaborative design environment. The design outputs from the idea generation and development activities during sessions three to five were analysed. The design brief was to improve upon the feedback and reward mechanisms within an existing maths game, which only included text-based feedback for getting the answer to the maths question correct or incorrect and did not include any reward for completing the game. For each of the three sessions (sessions three, four and five) the design team documented their feedback and reward ideas on three separate paper-based templates containing a screenshot of the current version of their game. Each of these templates represented ideas for feedback on correct answers, feedback on incorrect answers and a reward scheme for completing the game.

To explore the progression of these design ideas the outputs from each of the sessions were analysed (3 outputs x 3 sessions = 9 total outputs per team) and all ideas related to feedback or rewards were noted. These ideas were then categorised using the forms of reward proposed by Wang and Sun (2011) who compiled a list of eight different reward forms within games, based on the findings of multiple surveys and analyses of video games. These forms of reward also incorporate positive feedback, but did not include any form of negative feedback therefore a new category 'penalties' was generated to cover the negative feedback ideas included within the game. Table 5.3 presents the categories found within the design session outputs along with examples of ideas within each category.

Feedback and Reward Categories during game	Feedback and Reward Categories after game completion
Feedback messages e.g. speech bubbles, written feedback, sound effects, music	Feedback messages e.g. text-based praise, happy music, positive sound effects
Plot animations and pictures e.g. symbols, positive/negative images, game storyline, progress bar, colour changes	Plot animations and pictures e.g. fireworks, animated ending to game storyline, trophy, different coloured medals
Score systems e.g. lose/gain points	Achievement systems e.g. certificate, game stats, ranking, credits
Achievement systems e.g. increase/decrease other game characters opinion of player	Resources e.g. repairs, extra lives, extra functionality, upgrades
Penalties e.g. damage, disruption of game interaction, lose lives	Unlocking mechanisms e.g. new levels, customisation options

Table 5.3 - Categories of Feedback and Reward design ideas based on (Wang and Sun, 2011)

The findings from this categorisation showed that each of the design teams generated design ideas from at least one of these categories for both during the game and after the game completion in all of the sessions. It was possible to categorise all of the feedback and reward ideas within at least one of these categories, excluding the negative feedback ideas, which fell within the newly defined ‘penalties’ category. Table 5.4 shows the categories of ideas that were included within each team’s final prototype maths game. These results reveal that the TD teams and ASD team 2 were able to generate a wide range of different types of feedback/reward ideas that were deemed appropriate. ASD team 1 were still able to generate appropriate ideas, but these ideas were restricted to a limited number of categories. This may be due to the difficulties this team experienced in their initial idea generation as well as some children becoming fixated on specific ideas and struggling to progress from these. Therefore difficulties with imagination and rigid and repetitive behaviours may be areas in which some children with ASD require additional support in order to generate a greater variety of appropriate design ideas.

Feedback/Reward Category	ASD Team 1	ASD Team 2	TD Team 1	TD Team 2
Feedback messages	✓	✓	✓	✓
Plot animations	✓	✓	✓	✓
Score systems		✓	✓	✓
Achievement systems	✓	✓		✓
Resources		✓	✓	✓
Unlocking mechanisms		✓	✓	✓
Penalties	✓	✓	✓	✓

Table 5.4 – Categories of Feedback and Reward ideas included in the final prototype maths games

These findings demonstrate an ability to generate appropriate design ideas that can be classified within existing categories associated with providing feedback and rewards in computer games. However, it is important to note that all of the teams also generated further ideas to improve the game that were not directly linked to the feedback and reward mechanisms. The children were generally enthusiastic about the task and therefore would get carried away generating ideas for improving the game within other areas. It was difficult for the adults to maintain focus solely on specific game elements without negatively impacting the idea generation process by labelling some ideas as invalid within this context. Therefore it was decided since the children were also generating feedback and reward ideas that it was not necessary to intervene in relation to this issue.

Next the originality of the design ideas generated during sessions three to five was focused on. An idea was judged to be original if it did not fall into the same category as the feedback/reward mechanisms incorporated within the original game, but did fall within one of the other existing categories of feedback and reward defined above. The original game only contained written feedback messages, such as “You just shot a good guy” for negative feedback and “Got one! New Sum” for positive feedback (see Fig. 5.9). Additionally regardless of whether the player won the game or not, when the timer reached zero a “game over” message was displayed, with no form of reward given (see Fig 5.10).

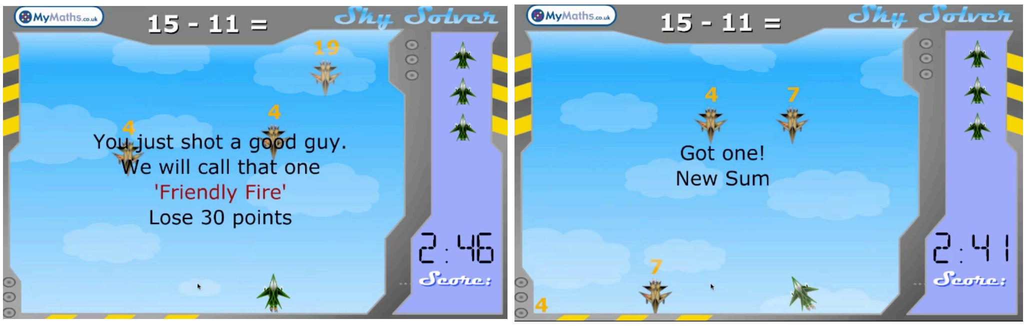


Figure 5.9 - Negative (left) and positive (right) feedback within original maths game

Figure 5.10 - Game ending

As the original game only contained feedback messages and no reward mechanisms any design ideas from categories other than feedback messages demonstrate some degree of originality. All of the design teams managed to achieve this, with ASD team 1 generating ideas from two feedback/reward categories during the game and three feedback/reward categories after game completion (both excluding feedback messages) and ASD team 2 generating ideas from four feedback/reward categories during the game and four feedback/reward categories after the game completion.

TD team 1 generated ideas from three feedback/reward categories during the game and five feedback/reward categories after the game completion. Finally TD team 2 generated ideas from three feedback/reward categories during the game and four feedback/reward categories after the game completion. There appeared to be slightly less variation in the ideas of ASD team 1 than the TD teams and slightly more variation in the ideas of ASD team 2. However, this further demonstrates the ability of children with ASD to generate both appropriate and original design ideas consistently across a number of sessions.

The analysis of the appropriateness and originality of the design ideas revealed that all of the design teams were able to generate appropriate ideas that fulfilled the brief to generate ideas for correct feedback mechanisms, incorrect feedback mechanisms and a reward scheme. Although it was discovered during session two that the children initially struggled with comprehending the concept of feedback within a game, separating out the feedback ideas into 'Ideas for what could happen if you get the answer right' and 'Ideas for what could happen if you get the answer wrong' appeared to greatly assist this comprehension with no child expressing confusion in this activity. Also the findings indicate that some children with ASD may require additional support in order to generate a greater variety of appropriate ideas. Finally all of the children were also able to expand upon the mechanisms incorporated within the original maths game and generate their own novel ideas, which incorporated a range of different feedback and reward mechanisms.

5.4.3 Educational Technology Design Implications

This section addresses the sub-research question **RQ1c) What specific implications do these design ideas have for designing educational technology aimed at an ASD population?** To explore this research question a thematic analysis of the final maths game prototype videos was undertaken guided by the technology design principles initially presented in Chapter Two. As with Study One the results of this analysis are then discussed in terms of their implications for each of the high-level design principle categories and specifically for the design of education technology for children with ASD. Within Study One it was difficult to determine how much the children's designs were impacted by their imagination or drawing ability and therefore no firm conclusions could be made on the basis of these findings. Within Study Two the children were not limited by their ability to produce the design idea prototype themselves as an adult provided additional support for both documenting initial ideas and then converting those ideas into a working prototype. This should therefore provide more reliable guidance as to the technology design preferences of children with ASD.

5.4.3.1 Visual Design

Animation and Sounds

Animation/Sound feature	**ASD teams**	**TD teams**
Animated story	✓	
Animated fireworks	✓	✓
Animated weather	✓	✓
Realistic animation	✓	
Flashing animations		✓
Speech	✓	✓
Cheering/Booing sound effects	✓	
Control of sound (inclusion/volume)	✓	
Background music	✓	✓

Table 5.5 – Animation and sound preferences of ASD and TD teams

Both the games designed by the ASD teams incorporated *animations* within the feedback mechanisms and reward scheme. Within the feedback this involved animations such as the plane doing a trick, but this animation was focused on one area of the screen. It was also important for them to include an animation as part of the reward scheme to provide an ending to the storyline of the game. ASD team 2 wanted animated story clips in between levels as a reward. Both ASD and TD teams wanted animated fireworks as part of their reward, and ASD team 1 along with both TD teams wanted some form of animated weather to indicate positive/negative feedback. Both ASD teams highlighted the importance of the animation looking realistic particularly in relation to the explosions and wreckage of the planes. Also one boy from ASD team 1 expressed a concern that the animation should not happen too frequently, which is in line with the principle that animation should not be used excessively. This was also reflected in the fact that both ASD teams chose to animate within one area of the screen avoiding additional animation that could distract attention away from the game focus.

One key difference between the ASD and TD teams was the use of flashing animation, both TD teams wanted certain interface elements to flash to draw attention to them, but neither ASD team mentioned this. The use of flashing animation could cause issues for children with ASD who have visual sensitivities.

Within ASD team 1 all of the feedback was visual as well as *spoken* aloud, but ASD team 2 did not want any of the feedback to be spoken. This preference was not as distinctive within the TD teams who both wanted some of the feedback to be spoken, but not all. ASD team 1 wanted cheering and booing *sound effects* in addition to the spoken feedback. A common theme that arose in both the ASD teams was the dislike for some specific sound effects, the children in ASD team 1 found balloon popping distressing and the children in ASD team 2 did not like constant high-pitched firework sounds. Both teams also highlighted the need to include functionality to control the inclusion and volume of the sounds within the game. This follows design principle 1.1, which states that certain sounds may cause anxieties in children with ASD and therefore should be used with caution.

All of the teams incorporated some form of background music, but ASD team 1 only used music for the reward scheme as they considered music to be too distracting within the game, again highlighting that there should be an option to turn this off. ASD team 2 stressed that only non-lyrical music should be included and it should not be imposing within the game. In contrast music formed a key part of TD team 1's game, preferring to include the latest chart music and having the ability to pick the songs that were played within the game.

Colour and Graphics

Colour/Graphical feature	**ASD teams**	**TD teams**
Theme-related colours	✓	
Bright colours		✓
Colour-based feedback		✓
Graphical feedback	✓	✓
Realistic graphics	✓	✓
Uncluttered interface	✓	

Table 5.6 – Colour and graphical preferences of ASD and TD teams

Both ASD teams used specific *colours* to reflect the theme of the game level, for example in ASD team 1 the colours of the Australian flag for the Australia themed level and in ASD team 2 the use of sepia tones for the World War 1 level. However, beyond this colour was rarely discussed, which was in contrast to the TD teams who both wanted lots of bright colours, with M9 from TD team 2 saying *"there should be lots of colours because it looks more fun and bright"*. This was particularly true within the reward scheme, with both teams mentioning rainbows and brightly coloured fireworks. They used colour to ensure there was a clear distinction between the player and enemy planes. TD team 2 also used colour to represent correct/incorrect feedback, saying "*green is good and red is obviously bad*". This indicates a difference between the colour preferences of children with ASD and TD children, supporting the design principle 1.2 that colours should be kept simple within technology aimed at an ASD population.

The incorporation of specific *graphical elements* to build up each game level theme was evident within both ASD teams, but within the TD teams each level used the same graphical elements. All teams used graphical feedback in addition to text and sound for instance in terms of the changing weather. The use of mini versions of the player's plane providing a concrete representation of the number of lives left was used in both ASD teams and TD team 1. These teams also all highlighted the importance of using realistic graphics, with both ASD teams highlighting specific details that needed to be correct such as the planes looking like they had really been shot and an old-fashioned newspaper not including a link to a website. This supports the design principle 1.3 that the graphics should be as realistic as possible for children with ASD and highlights the tendency of children with ASD to notice the finer details. ASD team 2 also highlighted the importance of the interface not being too cluttered, which follows design principle 1.1, which advises that the use of unnecessary graphics and animations should be avoided.

Icons, Symbols and Text

Few *icons and symbols* were incorporated into the children's game designs. Both ASD team 1 and TD team 1 wanted to incorporate a sound icon to control the volume, which is commonly used for this function within existing technology applications. ASD team 2 and TD team 1 both used a red cross to represent negative feedback. ASD team 2 also used symbols on crates containing bonuses to represent what was inside (i.e. a shield symbol for extra protection or first aid symbol for extra health) these symbols were inspired by the video games that the children were used to playing. However, the limited use of symbols does not support a preference for symbols as an alternative for text, although this may be different in other contexts.

All of the teams used *text* within their feedback mechanisms to varying degrees. ASD team 1 used a limited amount of simple text feedback. This was also all additionally spoken and therefore did not require the children to be able to read any of this text. ASD team 2 wanted to include some large chunks of text within their game that were not spoken, such as a newspaper article describing the current popularity of the player and descriptions of detailed game statistics within the reward scheme, which would require the player to have a good level of reading ability. There was also a variation between the TD teams in terms of the levels of text included within the game, with TD team 1 including a similar amount of simple text feedback to ASD team 1, but not all was spoken. TD team 2 included more text feedback, as well as a lot of text within their reward scheme, but neither included the large chunks of text that ASD team 2 did. This variation in text preference may reflect the children's own reading ability, which can vary substantially across the autism spectrum. Therefore it is important that the children are not required to read large chunks of text to make progress without providing additional support for this such as including the option to have it read aloud.

Age appropriate materials

The initial game involved shooting planes and there were a few potentially inappropriate ideas suggested by both ASD teams and TD team 1 such as having actual human characters dying, hearing people screaming and wanting to blow up lots of different things. However, since a teaching staff member was involved in each team they were able to moderate any inappropriate ideas, which were excluded from the final design to ensure the game would be suitable to be played within school. Another potentially contentious issue was the inclusion of the background music tracks within TD team 1 and the appropriateness of the language used in songs that are often popular with this age group. This again would be important to bear in mind, but may be less of a concern when designing for children with ASD who may find this type of music distracting and therefore not want it included in the game.

5.4.3.2 Feedback and Guidance

Task Structure and Control

The initial game was *highly structured* and all of the teams did not deviate from this structure. The game objective was very straightforward and the player only had a limited amount of control over what their plane could do (i.e. move left and right, and shoot). Most of the teams did not consider the inclusion of any additional scaffolding to provide further guidance within the game as they found it easy to understand. However, ASD team 1 did suggest the inclusion of an initial training ground level to help you learn how to play the game, which may provide a fun way for the children to scaffold the task of learning the game.

Feedback

Feedback mechanism	ASD teams	TD teams
Text-based	✓	✓
Penalties e.g. lose lives	✓	✓
Sound-based	✓	
Points-based	✓	✓
Use of more abstract mechanisms	✓	✓
Critical feedback	✓	

Table 5.7 – Feedback preferences of ASD and TD teams

A variety of different *feedback* mechanisms were used in each team's prototype game including text, graphics, animations, speech and sound effects. All teams used concrete textual feedback to show correct/incorrect answers such as "well done" or "bad luck try again", which were spoken aloud in the case of ASD team 1 and both TD teams. All teams also chose for the player to lose lives for incorrect answers and this loss was indicated using an animation of a plane flying away or disappearing or in the case of TD team 2 the number of their lives flashing. ASD team 1 also included cheering and booing sound effects to give positive and negative feedback. TD team 1 and ASD team 2 incorporated a points-based feedback mechanism frequently employed in games, gaining points for correct answers and losing points for incorrect answers. The teams additionally included more abstract feedback mechanisms with ASD team 1 and both TD teams using good/bad weather to indicate how well the player is doing. Also ASD team 2 using positive/negative newspaper articles to provide feedback to the player, with the game characters 'disliking' you if you were doing badly. This indicates that even though children with ASD can have difficulties in social situations they can still have a desire to be liked by others or be able to recognise this as a positive thing, which could be a motivating feature within the game.

All teams provided direct feedback on the player's actions, but design principle 2.5 also suggests the use of non-critical feedback for failures. In contrast the feedback mechanisms used in both ASD teams for incorrect answers could be construed as critical as ASD team 1 incorporates booing and ASD team 2 includes a negative newspaper article about the player, highlighting their unpopularity within the game. However, this may also indicate the need for the negative feedback to be more explicit and if the game provided less critical feedback the player may not realise they failed at a task.

5.4.3.3 Motivation and Engagement

Fun Features and Rewards

Fun feature/Reward mechanism	ASD teams	TD teams
Upgrades	✓	✓
Bonus levels	✓	✓
Storyline	✓	
Mini games	✓	
Random features	✓	✓
Trophy/Medal	✓	✓
Upbeat music	✓	✓
Positive text	✓	✓
Animated ending	✓	✓
Certificate	✓	
Leader board		✓
Statistics	✓	

Table 5.8 – Icon, symbol and text-related preferences of ASD and TD teams

There were a number of *fun and motivational features* that both ASD teams wanted to be incorporated within their games; these included the ability to 'upgrade' certain game features such as the player's plane and accessing bonus levels. The TD teams also suggested similar features. In addition to this ASD team 2 also wanted 'cut scenes' between levels, which were short animated videos giving more of the game storyline, mini games within the main game, random missions and randomised features such as the inclusion of different backdrops.

All of the teams incorporated animated fireworks, a trophy/medal, upbeat background music and some text saying something such as "well done" or "congratulations" into their *reward scheme*. Both ASD teams and TD team 1 also included some form of animated ending to the game, showing what happens to the pilot of the player's plane. This animation was particularly important within ASD team 2, who believed that the player discovering the ending to the story of the game would be rewarding in itself. Both ASD teams wanted the ability to print out certificates of their achievements within the game. Detailed game statistics were prominently featured within the reward scheme of ASD team 2, which would enable them to compare their performance within various elements of the game if they played the level multiple times. The bonus games and upgrades mentioned above would also form part of the player's reward in all of the teams' prototype games. Finally the competitive element of the game was important within TD team 2 and they wanted a leader board included which would enable them to compare their performance both nationally and internationally.

Personalisation

Personalisation feature	ASD teams	TD teams
Customise colours	✓	
Incorporate own photos	✓	
Customise music		✓

Table 5.9 – Personalisation preferences of ASD and TD teams

Both ASD teams wanted to be able to *customise* some of the colours within the game, with the children in ASD team 1 expressing differences in preferences between the boys and the girl, and ASD team 2 (as well as TD team 1) wanting to be able to customise their planes. These personalisation options arose from differences of opinion within the team and therefore they may be important for personalising areas where they did not agree, but this may not have been the case for other children. ASD team 2 also wanted to personalise the game by having the ability to incorporate pictures of themselves within it.

The children in ASD team 2 enjoyed having the opportunity to have their ideas included within a game and were very keen to be acknowledged within the credits, and the inclusion of this feature seemed to offer them a further opportunity to provide their individual input into the game. Therefore providing these types of personalisation options may be motivating for other children with ASD. TD team 1 particularly wanted to be able to personalise the music playing in the background, as this was one way in which they could express themselves. In contrast ASD team 2 specifically stated they did not want to be able to customise the music as one boy said "*if you can change the music it just doesn't feel right*". It appeared the children with ASD would prefer control over the volume/inclusion or exclusion of the music rather than being give the choice of what the specific music track actually was.

5.4.3.4 Participant Children's Final Game Evaluation

The children that participated in the design teams were not able to directly develop the prototype games and consequently the adult researcher had to make certain assumptions on their behalf when developing the prototype in between sessions. Therefore the children were asked to complete a survey during the last session to establish their opinion of the final prototype game, and to determine if it met their original expectations. This survey incorporated a Smileyometer Likert scale (see Fig. 5.11), a survey instrument designed by children for use in surveys for children (Read and MacFarlane, 2006). The Smileyometer was used to determine the children's opinions of the overall game and also specific features of the game such as the look, sound and animation.

The children in all four teams generally rated the specific game features as 'Really Good', with the exception of ASD team 1 who were less sure about the sounds and animation, and TD team 2 who were less sure about just the animation, but still rated it positively as 'Good'. All of the teams rated their final prototype games as 'Really Good' overall and all the children would definitely choose to play their games except for one boy from ASD team 2 and one boy from TD team 2 who both said they would maybe play. Children from all of the teams indicated that if they could change parts of the game then they would do:

- ASD team 1 would change elements of the sound, but were not able to give a reason why.
- ASD team 2 would change elements of the background because they did not like it and elements of the animation, sound and colour because they thought they had a better idea for it.
- TD team 1 would change elements of the animation because they did not like it and the colour but were not able to give a reason why.
- TD team 2 would also change elements of the animation because they did not like it and elements of the sound but again were not able to give a reason for this.

Figure 5.11 - Smileyometer Likert Scale used in surveys (Read and MacFarlane, 2006)

These results indicate that although the children were generally happy with what they had achieved, they still considered there was room for improvement in their games. Therefore if the number of sessions dedicated to designing and developing the game ideas was extended this may increase the appeal of the games to their wider peer group, as some of the more unappealing features may be down to the limited time the design team had to work on and refine these features within the game. Additionally enabling the children to build the game themselves would negate the need for an adult to make any assumptions on their behalf and exclude any incorrect interpretations of their ideas.

5.4.4 Appeal of Design Contributions

5.4.4.1 Design Contribution Evaluation Methodology

This section addresses the sub-research question **RQ1d) Do the design ideas appeal to non-participant children within the children's wider peer group?** As the participant children were acting as representatives for their wider peer group within the design process, it was important to establish the extent to which their design ideas were representative of this group. Therefore after the completion of Study Two the final prototype games were shown to the participant children's wider peer group to establish the general appeal of the design outputs within their target audience. Twenty children with ASD (aged 11-15 years, average 13 years, 18 male/2 female) from ASD School 2 and 3 and 20 TD children (aged 11-12 years, average 11 years, 8 male/12 female) from Mainstream School 2 were shown the prototype maths game videos that each of the design teams had produced.

This evaluation activity was undertaken with a class of TD children, but the children completed the activity individually. After watching each video they were asked to give the prototype game a rating out of 10. The children were then asked to undertake other activities not of direct research interest to divert attention away from the focus of the maths game videos. These activities included completing a questionnaire for an undergraduate research project and drawing out an idea for how to use the computer to teach a maths topic they were currently learning in class. The children were lastly given a set of four randomly ordered cards as memory aid for the videos (each representing one team's maths game), displaying three screenshots of each game, one from each of the prototype videos i.e. correct feedback, incorrect feedback and reward scheme (see Fig. 5.12). They were then asked to fill in the boxes on the back to provide a ranking for each game as well as give some rationale as to why they would or would not play the game.

The children with ASD undertook the evaluation activity individually with an adult researcher, but were not required to undertake the distractor activity as the videos were instead randomised for each individual to prevent any order effects. The children with ASD watched the videos and the researcher asked them to rate each video out of 10, which the researcher noted down. The children were then given the set of four cards (e.g. Fig. 5.12) and asked to place them in order of their favourite to least favourite game, and lastly asked if they would or would not play each game and why, which again the researcher noted down.

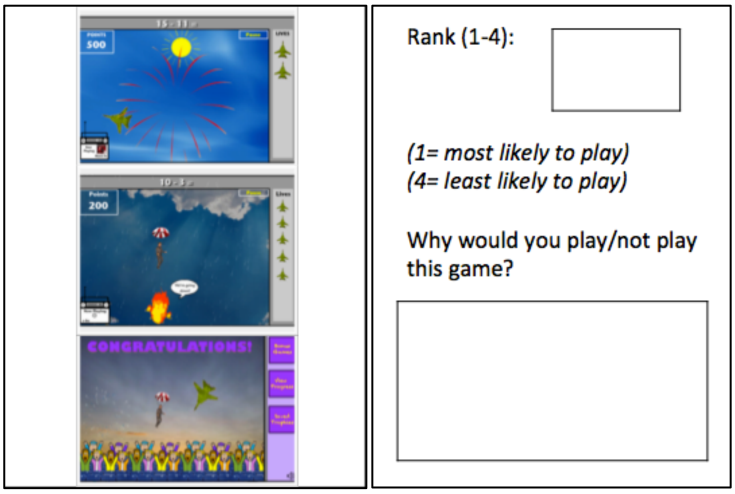
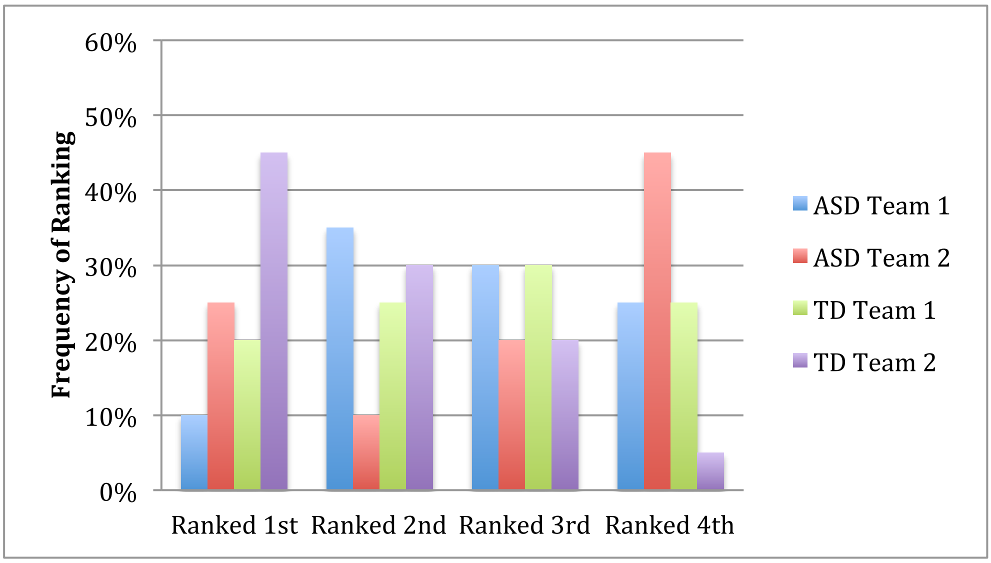


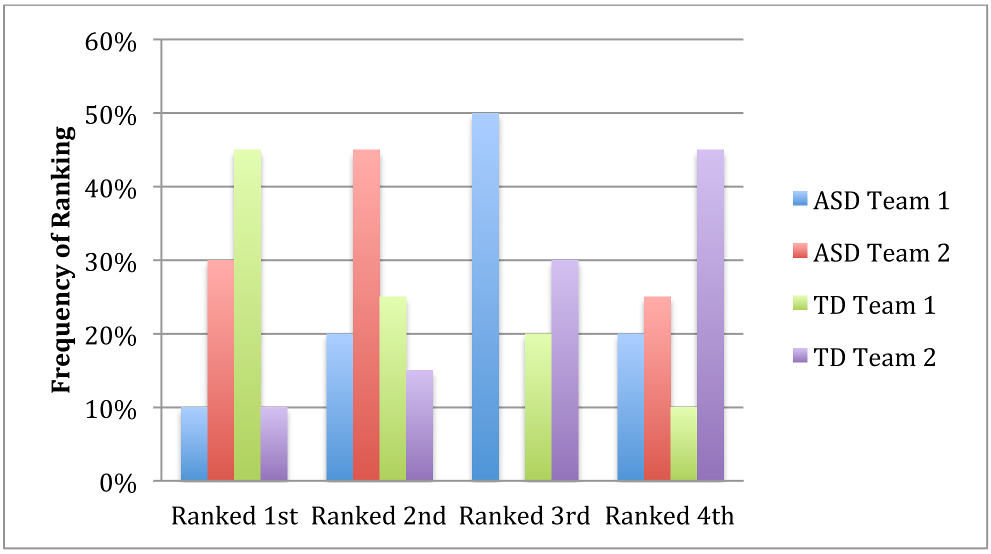
Figure 5.12 – Example card (front and back) representing one design team's prototype maths game videos

5.4.4.2 Design Contribution Evaluation Findings

The findings from the evaluation activity revealed that the ASD group demonstrated a preference for the game designed by TD team 2 with 45% of the children ranking it as their best game. The TD group showed a preference for the game designed by TD team 1 with 45% of the children ranking it as their best game. Interestingly, comparing Graph 5.3 and Graph 5.4, the TD group ranked the preferred game of the ASD group as their least preferred game, indicating a clear difference in the preferences of the two groups. The ASD group ranked the game designed by ASD Team 2 as their least preferred game, with 45% of the children ranking it as their worst game. However, the group had a mixed reaction to this game with a quarter of the children ranking it as their best game. Looking at the graphs overall the TD group demonstrate a clear preference in their rankings of the game, with 45-50% of the children giving the same ranking for each of the games. Whereas, although the ASD group demonstrated a general preference for their best and worst ranked games, there was much more variability in their responses.



Graph 5.3 - ASD group rankings of prototype maths games

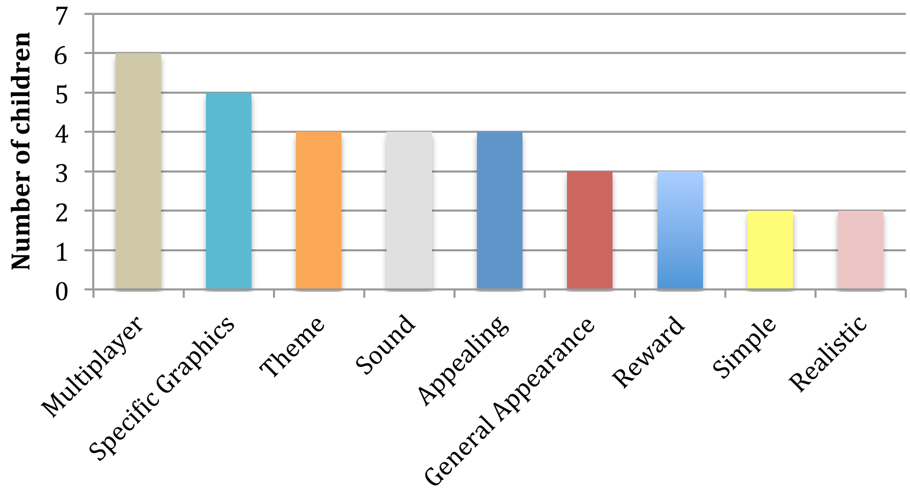


Graph 5.4 - TD group rankings of prototype maths games

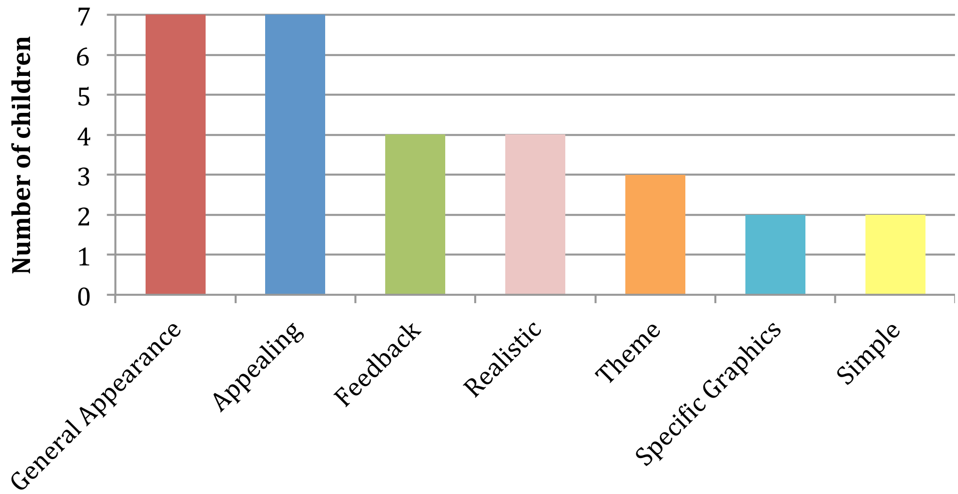
Reasons for Liking

During the evaluation activity the children were asked to give reasons for their rankings and say what they liked/disliked about the game. Graphs 5.5 and 5.6 below provide an overview of the reasons given across all four prototype maths games for what the TD group and the ASD group liked about particular games. Overall there were 37 different reasons given by children in the ASD group (12 categories) and 32 different reasons given by the children in the TD group (10 categories). However only the reasons given by two or more children have been included within the graphs as these reasons are more likely to offer insight into the preferences within their wider peer group and not be a result of the specific individual interests of the child, particularly in the case of the children with ASD with very narrow interests. The graphs show a clear difference between the most popular reasons for liking a game between the ASD and TD groups.

Firstly there was a wider spread of reasons within the ASD group, with the most popular reason being cited by six children, whereas within the TD group the same reason was cited 11 times. The ASD group expressed a preference for multiplayer games. They also expressed a liking for specific graphical elements within the games, a liking for a specific theme (such as the space or Australia themes) or the variety of themes within the game, as well as a liking for the background music used within the game. In contrast the general appearance of the games influenced the TD group's preferences, with many stating they liked a game because it looked good, they liked the colours or the way the game was laid out. They also liked certain games because they found them appealing in some way, specifically finding them fun, entertaining or exciting.



Graph 5.5 - Reasons given by two or more children from ASD group for liking prototype maths games



Graph 5.6 – Reasons given by two or more children from TD group for liking prototype maths games

Reasons for High Ranking

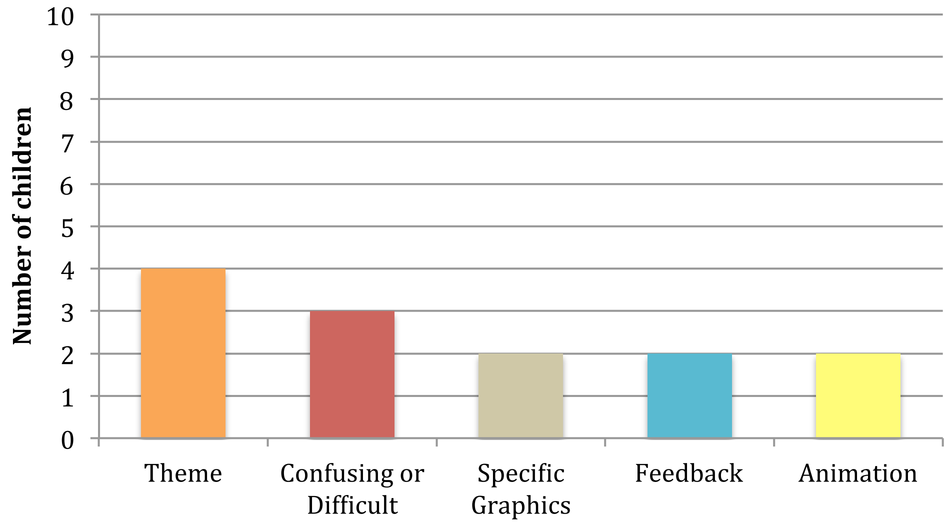
Looking specifically at the reasons behind the highest ranked game from each group the ASD group preferred the game designed by TD team 2 because it was multiplayer and the other games were not. This reason was given six times and was by far the most common, as all other reasons were only cited once or twice. Not a single child from the TD group commented either positively or negatively on the multiplayer aspect of this game. Considering the difficulties children with ASD can experience with social and communication skills, it could be viewed as surprising that they would prefer to play a game with someone else. However, they may prefer the structured interaction that computer games can offer, as the role of each player within the interaction is made clear and also that the social interaction is not face to face. This highlights the potential of using technology to motivate social interaction in children with ASD.

The TD group preferred the game designed by TD team 1, with the most common reasons the same as those across all of the games, considering the overall game rather than specific features. Five children liked the general appearance of the game stating it was colourful, looked good, was detailed and they liked the layout. Five children also found the game appealing stating it was fun and would keep you entertained. All other reasons were only cited once or twice.

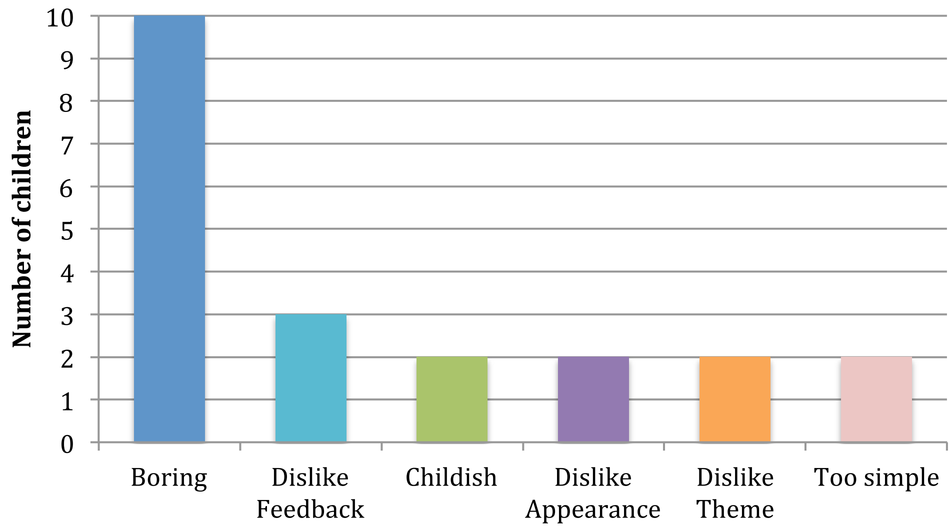
Reasons for Disliking

Graphs 5.7 and 5.8 below provide an overview of the reasons given across all of the prototype maths games for why the TD group and the ASD group disliked particular games. Overall there were 17 separate reasons given by children from the ASD group (9 categories) and 28 different reasons given by children from the TD group (13 categories). However, again only the reasons given by two or more children have been included within the graphs. The lower number of reasons given by the ASD group indicates there was potentially a more general liking for all of the games than within the TD group. There were two main reasons for the children disliking particular games within the ASD group. Four children disliked a game because of the theme and three children disliked a game because they found it confusing or difficult.

In contrast a large proportion of the TD group (10 children) specified the same reason for disliking a particular game, which was that they found it boring and this was again an overall assessment of the game rather than a focus on specific features.



Graph 5.7 - Reasons given by two or more children from ASD group for disliking prototype maths games



Graph 5.8 – Reasons given by two or more children from TD group for disliking prototype maths games

Reasons for Low Ranking

Looking at the lowest ranked game within the ASD group (which was the game designed by ASD team 2) the main reason for disliking this game was because of the theme and all children specifying the theme as a reason did so in reference to this game, with three of the four children specifically saying they did not like the World War 1 theme. This theme was incorporated because one of the children within ASD team 2 had a special interest in World War 1. However, this is a very narrow interest and would not necessary generally appeal to the wider ASD population, which indicates a need to potentially incorporate the option for the children to select from a number of different themes. All other reasons were given by only one or two children.

The lowest ranked game within the TD group was the game designed by TD team 2 and the main reason for disliking this game (as with the games in general) was that they found it boring (stated by five children). However, it was difficult to know what they specifically found boring about it, as these children did not elaborate on their answers. With regards to this game there was a large disparity in the views of the TD group and the ASD group. This game was the highest rated game within the ASD group with only two of the 20 children within this group saying something negative about it and none of the children stating that they found it boring. This highlights a clear difference in preferences between the two groups.

5.5 Summary of Design Contribution Findings from Study Two

This chapter has described the refinements made to the IDEAS method for use within a collaborative design environment and discussed the design contribution findings from Study Two, which involved four design teams who followed this refined version of the IDEAS method. The key findings from this chapter are summarised below, presented under each of the sub-research questions that guided the analysis.

5.5.1 Relevance to Research Questions

RQ1a) Do children with ASD require any form of support in order to generate and/or communicate their design ideas?

The analysis of the support required for the idea generation activities emphasised the need for different methods of idea expression to be available within the IDEAS method. The children with ASD had a wider range of needs (e.g. writing and sensory issues) that required support within this activity and there were also different preferences (e.g. writing, drawing, verbal) across the teams with regards to the children's choice of expression. The need for direct prompts to provide a more specific focus for the idea and motivational support to encourage the contribution of design ideas was also highlighted, particularly for some of the children with ASD. WCC theory (Happé and Frith, 2006) provides a potential explanation for the need for direct prompting to reduce the scope of the design space, as the children prefer to concentrate on the details and have difficulties understanding the bigger picture, they could initially struggle with generating ideas at too high a level. Therefore beginning with specific details and gradually building up to the bigger picture may be a more appropriate approach to idea generation.

There was a varying need for adult support within the teams, which also typically decreased as the sessions progressed. This demonstrates the requirement for the adult's supportive role to be flexible and also that it could potentially change over time, which could also be related to the dynamic nature of teamwork.

RQ1b) Are children with ASD able to generate design ideas, which are both appropriate and demonstrate some level of originality?

The analysis of the appropriateness and originality of the design ideas revealed that the children with ASD were able to generate appropriate ideas that fulfilled the brief to generate ideas for correct feedback mechanisms, incorrect feedback mechanisms and a reward scheme. It was possible to classify the ideas generated by the children into a set of existing reward form categories defined within the computer game literature. However, the children also generated more general game design ideas that were not linked to feedback and reward mechanisms, but were intended to improve the overall look and feel of the game. This highlights a difficulty maintaining a focus solely on specific game elements, but this was an issue for both ASD and TD teams so cannot be directly linked to any theory of autism. The children also demonstrated the ability to expand upon the features incorporated within the original maths game and generate their own novel feedback and reward ideas that were different from those included within the original game.

RQ1c) What specific implications do these design ideas have for designing educational technology aimed at an ASD population?

The analysis of the final prototype maths games revealed, in terms of implications for educational technology design, that it was important for animated and graphical elements to be realistic. The inclusion of sound raised the issue of causing distractions or aggravating individual sensitivities and therefore it was important for the children to have control over this. There appeared to be a wide variation in the reading ability of children with ASD highlighting a need for any text to be additionally spoken aloud, and to ensure there is not a reliance on reading large chunks of text to enable successful interaction with the technology.

The children with ASD appeared to want more explicit feedback than the TD teams, particularly with regards to their ideas for the negative feedback, which could be construed as overly critical by some more sensitive children. Children with ASD can often be brutally honest (Landa, 2000) and there can be an expectation that others, or in this case the technology, would behave in the same way. Therefore ToM (Baron-Cohen, 2000b) could provide a potential explanation as to why they would prefer or expect more critical negative feedback.

Finally the issue of different preferences was raised during the sessions with the ASD teams as the children expressed a liking for different ideas, and indicated that the incorporation of personalisation options could be motivating. These different preferences could be related to the narrow obsessional interests of children with ASD, due to difficulties in switching attention as suggested within the ED theory (Ozonoff et al., 1991) or alternatively because of a drive to understand ‘systems’ as proposed within the E-S theory (Baron-Cohen, 2009). Though this could alternatively be explained by the individual differences between children that also are typically found within the general population.

RQ1d) Do these design ideas appeal to other children within the ASD population?

The analysis of the results to determine the appeal of the prototype games both within the design teams and across the children’s wider peer groups revealed a clear difference in the preferences of the ASD and TD groups. There was also a wider variability in the preferences within the ASD group than in the TD group, as well as a wider spread of more specific reasons for liking the games. This highlights the high level of individuality within ASD and the difficulty of generalising anything for this population. These results reflect a similar pattern to the preferences shown in Study One, with the TD group expressing preferences for the overall game in contrast to the ASD group focusing more on specific features of the games. This could be explained by the WCC theory (Happé and Frith, 2006) and a tendency to focus on the finer details, or the E-S theory (Baron-Cohen, 2009) and a drive to understand 'systems' (in this case the maths game) by focusing on the individual components of the system.

One of the main reasons for the children with ASD disliking a game was the theme. This was predominantly due to a particular theme, which related to the special interests of one of the participant children with ASD. Both the ED (Ozonoff et al., 1991) and E-S theories (Baron-Cohen, 2009) highlight the unusual and narrow interests frequently observed in ASD. Therefore allowing the theme to be personalised may be necessary in order for a game to appeal to a wider cross-section of the ASD population, as there can be less commonality in interests.

5.5.2 Summary

The findings discussed within this chapter again highlight the need for different modes of expression and also the flexible role the adult needs to undertake, particularly in providing direct prompts and motivational support early on. These findings indicate that children with ASD do have the ability to generate appropriate and original design ideas, which have appeal within their wider peer group. However, the non-participant children with ASD who evaluated the design ideas had a tendency to focus on specific features of the design and were also divided in their opinions over the game themes. This highlights a need to ensure the finer details of the technology are considered carefully and also to incorporate options to personalise specific areas to enable a more general appeal.

One key outcome was that although the participant children were generally positive about their own games, there were still a number of improvements suggested. This indicates that perhaps the limited time or inaccurate interpretations by the adult researcher may have resulted in the game ideas not being developed to fully match the children's original design ideas and expectations. Consequently, if the children had been enabled to build the game themselves this may have increased the appeal of the game within the children's wider peer group. The potential of enabling the children to implement their own games ideas also offers a number of other possible benefits, which include increasing the children's level of participation within the process and providing them with an additional skill that they can develop throughout the design process. This could potentially contribute to their increased sense of empowerment as a result of their participation. This idea was therefore explored further within Study Three and is introduced in the next chapter.

Chapter 6 Study Three: Collaborative Design and Build Contributions

6.1 Introduction to Study Three

Study Three further examined the ability of children with ASD to make design contributions within a collaborative design environment. This study extended the design context to additionally incorporate the implementation of the prototype within the sessions, allowing the children to design *and build* their own game. It was hoped that by allowing the children greater involvement within the development of the prototype technology this would reduce the likelihood of design ideas being missed or incorrectly interpreted by adults, as well as potentially increasing the appeal of the final prototype within the children's wider peer group.

The first two studies indicated that children with ASD had the ability to generate and communicate design ideas both within an individual and collaborative design environment. Study One highlighted the difficulties some children had starting with a clean-slate design task. Therefore Study Two provided a starting point, additional structure and a narrower focus within the idea generation process, which helped to overcome the issue of children being overwhelmed with an open design task. Within Study Three the design task was further manipulated to establish if the children would be able to generate and communicate design ideas within a 'structured' clean-slate design task. The design teams were provided with guidance for the different elements of the design task and provided with a very basic starting point (if required), but allowed freedom within the idea generation process. Achieving a suitable balance between support and creative freedom is important to ensure the children are not overwhelmed with the task, but are also not restricted in their creativity.

This chapter builds on the *design contribution* findings from the previous two chapters in respect to **RQ1) Can children with ASD successfully generate and communicate *design ideas* and what implications do these ideas have in terms of designing educational technology for children with ASD?** The importance of the children's ability to generate and communicate design ideas in enabling them to make a greater contribution to the technology design process has been established in the previous chapters. In this chapter this research question is further explored in relation to the contributions made from a collaborative design environment, which incorporates a structured clean-slate design task and is focused on both the design and build aspects of the prototype technology. Study Three followed a similar setup to Study Two with regards to the composition of the design teams. However, the Study Three teams included two existing teams who had previously participated in Study Two (one ASD team and one TD team) and two newly formed design teams (again one ASD team and one TD team). Study Three additionally aimed to explore this difference in previous experience of participating within this type of collaborative design environment, to establish if this experience can positively impact the children's ability to generate and communicate design ideas.

The IDEAS method has also been further refined to incorporate the findings from Study Two and to allow the prototype technology to be implemented within the design sessions, which is a further contribution of this thesis. These modifications are discussed below and followed by a description of the study methodology.

6.2 Further Refinement of the IDEAS method

The refined version of the IDEAS method continued to use the TEACCH Structured Teaching approach as a framework and is presented diagrammatically within Fig. 6.1 on the following page, with the additional modifications highlighted in blue. This version of IDEAS was again developed for use over a series of six PD sessions with a design team incorporating three children, two university researchers and one teaching staff member from the children's school.

There were three key changes related to the further exploration of **RQ1**. Firstly, the *idea generation templates* used during session three were changed to allow the children to generate ideas separately for each element of the design topic, continuing to provide structure but also additional creative freedom. Furthermore, these templates contained a visual sample interface design to provide a starting point for the children if they required it. The children were provided with a blank interface design template framed by a computer screen on which to draw out the interface of their chosen ideas, to provide additional help for the children in imagining how their ideas would be displayed on the computer.

Secondly, new implementation activities were incorporated into the method to allow the children to take on a more involved role within the process by building the prototype themselves.

The *concept of programming* was introduced through games and also through a tutorial in the programming environment the children used. This was undertaken before the idea generation began, so the children were able to take into account what they may be able to build when they began generating ideas, potentially resulting in a more feasible outcome to this session. The children were also given the responsibility of generating the activity list on the visual schedule for the build session, to give them a greater sense of empowerment over the process by allowing them to set their own goals.

Thirdly the *physical environment setup* was designed to encourage collaboration between the children, providing them with a single template to jointly draw their interface design on. Additionally the children were required to share access to a computer in order to build their design ideas. A wireless keyboard and mouse as well as a large external monitor was provided to facilitate the sharing of resources and allow all children to easily monitor the team's progress throughout the session.

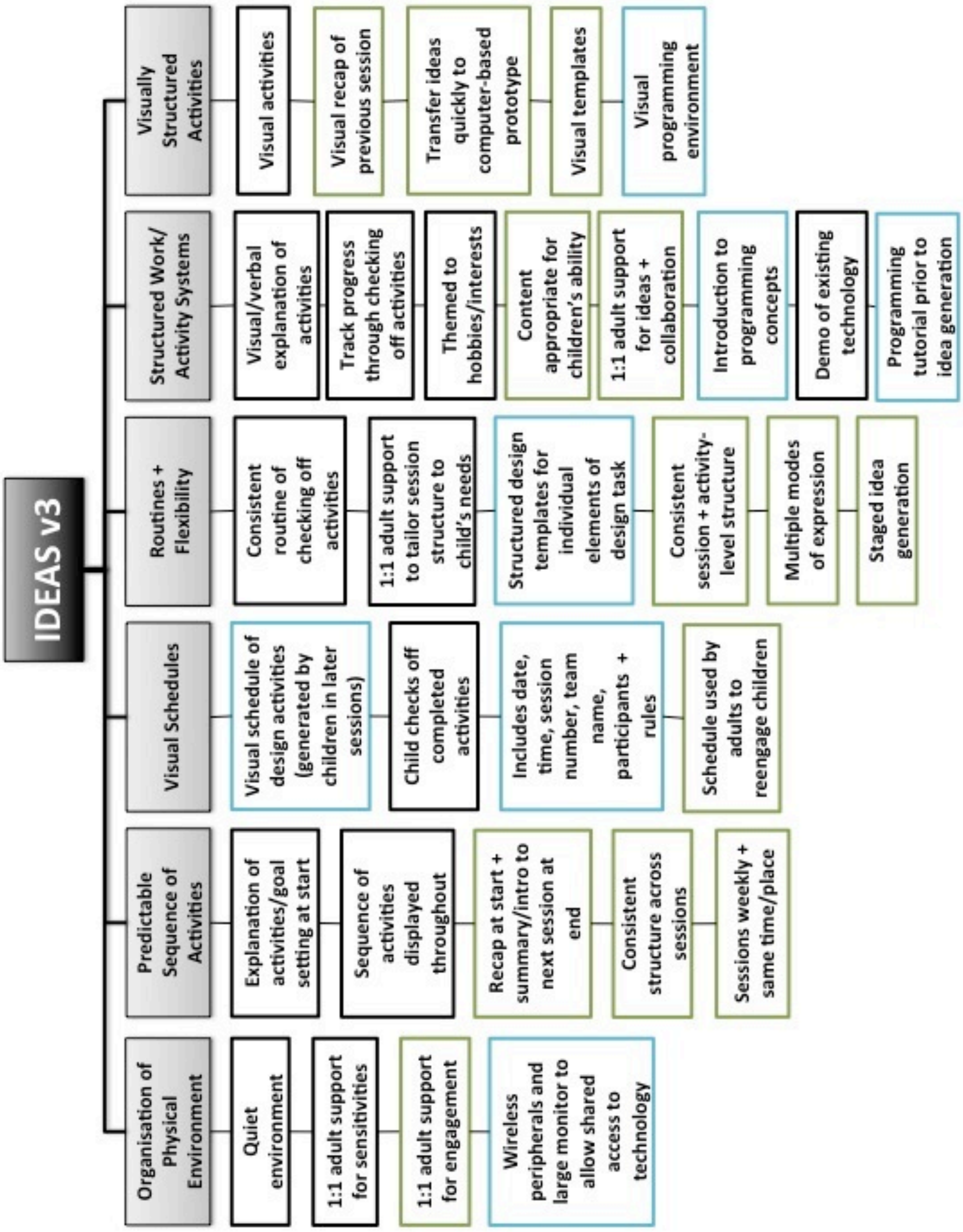


Figure 6.1 – Refined version of IDEAS method used in Study Three (refinements highlighted in blue)

6.3 Study Three Methodology

6.3.1 Participants

Study Three involved four separate design teams, two teams incorporating three boys with HFA/AS aged 13-14 years from ASD School 3 and two teams incorporating three TD boys aged 12-14 years from Mainstream School 2 (see Table 6.1). The difference in the ages of the ASD and TD children was not statistically significant (t_{11}=0.7, p>0.05). The ASD and TD teams were matched on verbal IQ, with the verbal IQs of the children with ASD ranging from 89-128 and the TD children ranging from 91-125. The difference in the verbal IQs of the ASD and TD children was not statistically significant (t_{11} = 0.8, p>0.05).

Team Name	Child Participant 1	Child Participant 2	Child Participant 3
ASD Team 2	M3 aged 13, VIQ=89	M4 aged 13, VIQ=89	M5 aged 13, VIQ=98
ASD Team 3	M11 aged 14, VIQ=114	M12 aged 12, VIQ=128	M13 aged 13, VIQ=101
TD Team 2	M8 aged 13, VIQ=91	M9 aged 13, VIQ=96	M10 aged 12, VIQ=98
TD Team 3	M14 aged 13, VIQ=114	M15 aged 13, VIQ=125	M16 aged 14, VIQ=105

Table 6.1 - Overview of Child Participants in Study Three

Two of the teams (ASD team 2 and TD team 2) had taken part in the previous study, therefore the children in these teams already knew each other well, and two were new design teams. The children in ASD team 3 were classmates and as before the children in TD team 3 were selected based on their age, gender and verbal IQ match. Two of the boys in TD team 3 already knew each other well, but they did not know the third boy who was in different year group. Each team again included two adult researchers as well as a teaching staff member from the children's school. The teaching staff member in ASD team 2 and 3 was the same teaching assistant who had participated in ASD team 2 during the previous study, and was familiar with all of the boys. The teaching staff member in TD team 2 and 3 was the same maths teacher who had participated in TD team 2 during the previous study, and was familiar with the boys from that team but was not familiar with the boys in the new TD team.

The teams undertook the sessions within a separate room away from their classroom, this was always the same room for the ASD teams, but for the TD Teams this changed each week due to high demand for rooms at the school. The children in the ASD teams had agreed to participate instead of doing one of their PE (Physical Education) lessons for six weeks. The children in the TD teams missed a number of different lessons due to the variability of their timetable and a requirement for them to not miss too many of the same lesson. Fig. 6.2 shows the typical setup for each of the teams.

ASD Team 2

ASD Team 3

TD Team 2

TD Team 3

Figure 6.2 - Study Three setup for each of the teams

6.3.2 Data Collection Methods

Each of the design sessions was videotaped, after providing detailed information about the use and storage of the videos to the participating schools and gaining appropriate consents for this. Parents of the child participants were also sent letters explaining the project aims, and their child's role within the project, ensuring they were aware that their child could be withdrawn at any point if necessary.

As in the previous studies prior to this study the 13-point ethics checklist required by the University of Bath Computer Science Department when involving participants in research was completed and can be found in Appendix B. The wider project that this work formed part of also met the British Psychological Society ethical code and was approved by the Department of Psychology and University of Bath ethics committees.

6.3.3 Procedure

During Study Three each team undertook a series of six design sessions on a weekly basis, with each session lasting approximately one hour and being conducted at the children's school in a quiet room separate from their classrooms. The sessions all followed the refined version of the IDEAS method outlined below, with modifications made based on the findings from the previous study. A whiteboard-based visual schedule was again used to display the list of activities for the session, date and session number as well as the team name, rules and team portraits. One child per session was assigned (or volunteered for) the responsibility of checking off the tasks. Each session similarly began with a visual recap of the previous session, except for session one which instead began with a visual overview of what each of the six design sessions would involve. For this study the teams were set the task of designing and *developing* a maths game for their peers. This game was not required to be based on an existing game and as part of the sessions the children were taught to use a children's programming environment called Scratch, which they could use to build their final game. Scratch was chosen as it is a widely used children's programming environment and is also freely available online so the children could further develop their game after the study if they wished to.

Below is a description of the six design sessions that each of the design teams in this study undertook:

- **Session 1 (Team Building)**: this session began with the same team portrait drawing activity used during the previous study. The new design teams were then asked to agree a team name, and generate a set of rules to be followed during the sessions. The existing design teams were given the opportunity to change the rules they agreed during the previous study. The teams then played a programming logic-based iPad game, called Robologic (see Fig 6.3). This game involved dragging and dropping a sequence of actions into the boxes on the right-hand side of the screen to correctly direct the robot to turn on all of the lights. The child participants rotated control of the iPad after each level, with the other two children asked to verbally assist.

Figure 6.3 - Screenshot of Robologic game

- **Session 2 (Context Setting)**: this session began with demonstrations of three existing maths games on the iPad, Math Racing Turbo, Rocket Math and Math Party (see Fig. 6.4). Math Racing Turbo is a one-player game that involves answering a number maths questions to complete the race. Rocket Math Rocket is a one-player game where you decide on a mission, complete the maths questions to earn money to buy accessories for your rocket and then launch it. Math Party is a two-player game, which involves touching the circles in size-order faster than your opponent. The child participants were allowed to trial each game and then asked to discuss the good and bad points about each one. Next the participants were introduced to the Scratch programming environment, which was setup on a laptop computer connected to a large monitor, and wireless keyboard and mouse to allow easy access by all participants. The teams followed a tutorial to further develop a basic 'Pong' game, which was an example game available by default within the initial installation of Scratch. The tutorial involved learning a range of functionality including modifying the sprites, background, graphic effects and sounds, as well as learning about buttons, broadcasts and variables. The full tutorial can be found in Appendix D. The participants took turns to complete each of the tutorial tasks.

Figure 6.4 - Demonstration maths games (from left to right): Math Racing Turbo, Rocket Math and Math Party.

- **Session 3 (Idea Generation)**: this session began with the demonstration of a basic platform game (which did not include maths), another example game available in Scratch, which provided a basis for idea generation. The participants could generate ideas based on this game, but were also free to generate unrelated ideas if they wished. Each team member was provided with a paper-based template (see Fig. 6.5), on which they were firstly asked to note down their individual ideas for different game themes. This process was then repeated for five other game elements, which included game characters, maths topics, feedback, reward scheme and sounds. These completed templates were then used to guide a group discussion, with each element discussed in turn and team members sharing their own individual ideas. The participants were asked to agree on their chosen idea(s) for each game element and this was noted down by one of the adults on a separate paper template. Lastly, the child participants were provided with a paper-based computer interface template (see Fig. 6.6) and asked to draw out what they wanted their game to look like.

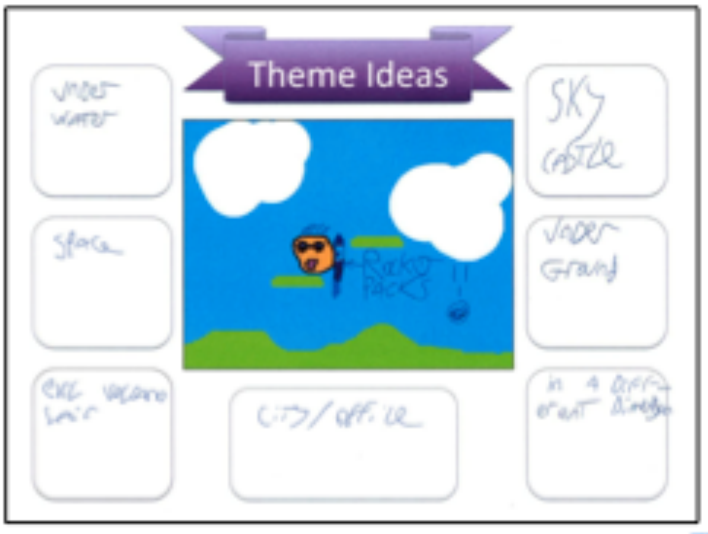


Figure 6.5 – Example Individual Idea Template for Theme Ideas

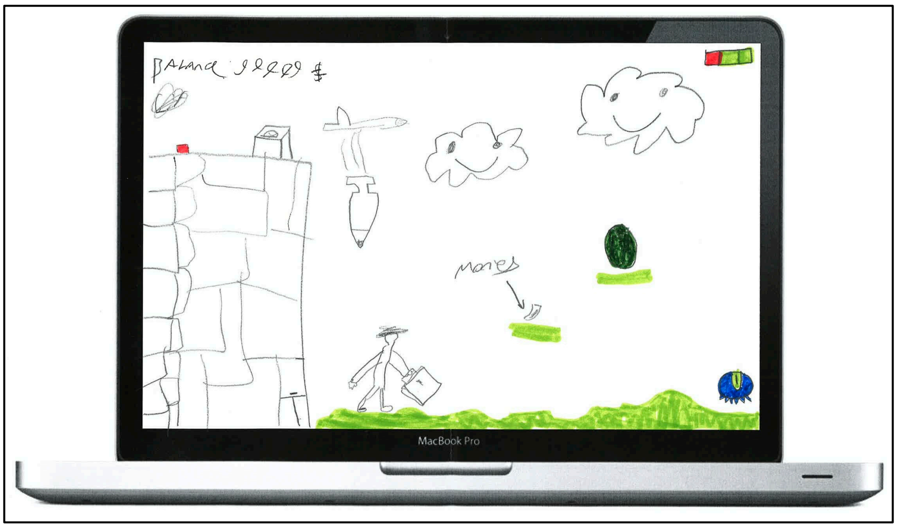


Figure 6.6 – Example Interface Design Template

- **Session 4 (Design Development)**: this session began with a recap of the team ideas agreed during the previous session. The child participants were then asked to think about the game development tasks they needed to focus on first and agree a list of activities that needed to be completed during the session, which were written on the whiteboard-based visual schedule. The laptop computer was setup the same way as described in session two and the children were then asked to begin building upon the basic platform game in Scratch, by following their agreed task list to turn it into their game idea.
- **Session 5 (Design Refinement)**: in a similar way to session four at the start of this session the child participants were asked to agree a list of tasks that

needed to be undertaken to complete their maths game in Scratch and write these on the whiteboard-based visual schedule. They were then asked to finish as much of their prototype game in Scratch as time allowed. At the end of the session the researchers asked the children if there was anything they did not have time to finish or incorporate. These features were noted down and one of the researchers finished the game prior to the last session.

- **Session 6 (Evaluation and Reflection)**: this session began with the child participants being given the opportunity to trial the final version of their game. They were then asked to complete a survey to establish their opinions of the final game (see Appendix C), which again incorporated a Smileyometer Likert scale (Read and MacFarlane, 2006). The children completed another survey to establish their opinions of their participation experience and the participant teaching staff member also completed a survey to establish her opinion of the sessions and if the children benefited in any way (see Appendix C). Finally the children were asked to produce a display of work to show their class teacher what they had achieved over the past six sessions. They were provided with paper templates to help guide the discussion in four different areas, the success of the *team*, the *activities* they had completed, the *ideas* they had generated, and the *final game* they had produced. The children were also provided with a set of related images and asked to match and stick the images to the corresponding template. They were then asked to discuss and complete the text boxes on the templates, which asked a series of questions about their opinions within the four discussion areas. The templates can be found in Appendix E. All of the children were given certificates, a small gift and a copy of their game to thank them for taking part.

It is important to note that within ASD team 2, one boy left the school after session two and so was unable to participate in the remaining sessions. Also one of the boys from ASD team 3 was unable to participate in the final design session and so the data relating to his opinion of the final game is unavailable.

6.3.4 Outputs and Analysis

In order to address **RQ1** the outputs from Study Three were analysed (see Table 6.2). The analysis of each output has been guided by a series of sub-research questions, which are noted within Table 6.2 and discussed in further detail below.

Output	**Sub-Research Question**
Completed individual and team idea templates	RQ1a, RQ1b
Digital video of Session Three	RQ1a
Final Scratch-based prototype games	RQ1c
Completed Final Game survey from participant children	RQ1c
Non-participant children's ratings/ranking of final game prototypes	RQ1d

Table 6.2 – Outputs of Study Three and related sub-research questions

RQ1a) Do children with ASD require any form of support in order to generate and/or communicate their design ideas?

To address this sub-research question the completed templates containing the children's individual game element ideas and all the teams' collectively agreed game element ideas were analysed to establish how the children documented their ideas and what support they required to do this. Additionally the video of session three, when the design ideas were generated, was analysed to determine the types and level of support the children required during the idea generation process.

RQ1b) Are children with ASD able to generate design ideas, which are both appropriate and demonstrate some level of originality?
To address this sub-research question the completed templates containing the children's individual game element ideas were analysed against each of the six game element categories (Theme, Characters, Reward, Feedback, Sound, Maths Topic) to establish if the children were able to generate appropriate ideas, i.e. ideas that fitted into each corresponding game element category. Also to establish if they could generate their own ideas that either extended the basic game starting point or that were completely novel.

RQ1c) What specific implications do these design ideas have for designing educational technology aimed at an ASD population?
To address this sub-research question the final prototype games produced by each design team were analysed alongside the participants children's opinions on the final prototype games collected within the Final Game survey undertaken during the last design session. This was done to establish any visual design, feedback and guidance, and motivation and engagement preferences and based on these preferences what the resulting implications for educational technology design may be.

RQ1d) Do these design ideas appeal to other children within the ASD population?
To address this sub-research question videos of the final prototype game were shown to a group of children with ASD and a group of TD children, who all had not participated in the study, to establish their opinions of each team's game design. The results of this evaluation activity were analysed to determine which game designs were most appealing to each peer group.

The findings from this analysis are described in more detail below.

6.4 Design Contribution Findings

6.4.1 Support for Idea Generation and Communication

This section addresses the sub-research question **RQ1a) Do children with ASD require any form of support in order to generate and/or communicate their design ideas?** In Study Two it was established that the children with ASD were able to generate and document ideas within a collaborative design environment. However, it was found that some children had issues with writing and drawing their ideas, as well as some confidence issues with expressing ideas verbally. Therefore it was important that a number of forms of expression were available within the idea generation activities. Adults were also required to provide a certain amount of direct prompting and motivational statements to support the children during their idea generation and in communicating these ideas.

Study Three builds on these findings by expanding the design space in which the ideas were generated to incorporate ideas for a variety of different game elements instead of solely for the feedback and reward elements. It also provides a less developed starting point to allow the children more creative freedom in their idea generation. To reduce the reliance on adult prompting more support was provided through consistently structured paper-based templates for each of the different game elements. These templates allow the children to either write or draw initial ideas and then use the completed templates as a reference point within the group discussion where they could expand upon their ideas verbally. As Study Three also incorporated game building sessions, the exploration of the idea generation and communication is focused upon session three (see section 6.3.3) when the initial game ideas were generated, discussed and collectively agreed. The support provided for both generating and documenting these ideas was explored.

6.4.1.1 Support for Generating Ideas

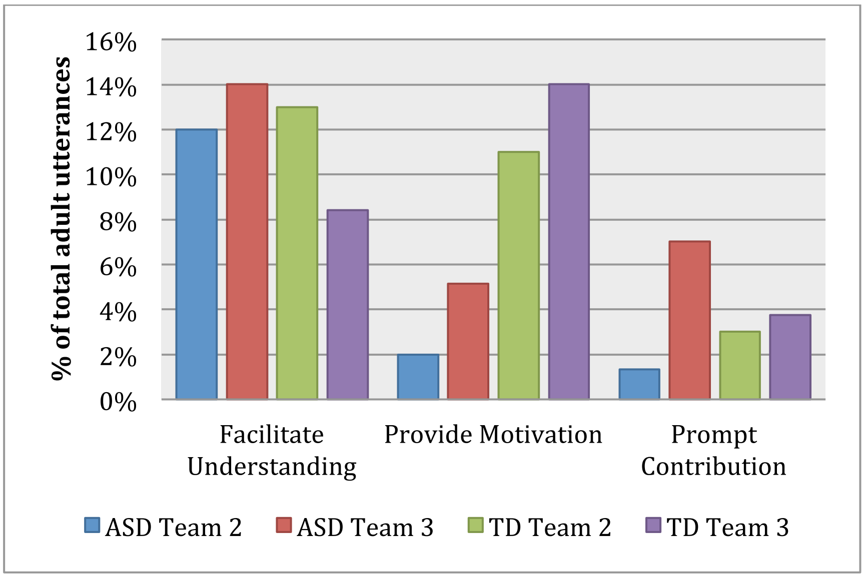
As with Study Two the adults again supported the children during the idea generation through explicit prompting of individual children and by using motivational language. As before the transcripts from sessions three, four and five were analysed by coding any utterance (a sentence or number of sentences without any explicit pauses or interruptions by other team members) where an adult directly prompted a child to contribute an idea, e.g. "Cool, M14 any other ideas for characters?" and also when they praised a child's idea e.g. "I love it, ah brilliant!" or provided more general encouragement to the entire team, e.g. "I see why I need you guys, I would never have come up with something like this on my own". These were the same codes that were used within Study Two. However, during this analysis a third category of support emerged, whereby the adults would provide further explanations, examples and clarifications of the design task to facilitate the child's understanding of the task. This could be either in response to a child explicitly asking for help or recognising that a child is struggling with the task in some way, e.g. not generating any ideas or generating inappropriate ideas which are unrelated to the design brief. Therefore a second pass of the transcripts was undertaken to code this third category of support. Each utterance was coded only once. In terms of support to facilitate the children's understanding of the task, (which was the most common category of support) a number of support types were observed, which included:

- Clarification: *"Adult: So if you write that down and we can discuss them at the end."*
- Reassurance: *"Child: I've kind of done that on the other sheet. Adult: Oh that's ok."*
- Refocus: *"Adult: You need to think if it is going to fit within the game."*
- Answer questions: *"Child: Do I have to fill them all out? Adult: No it's just in case you have lots of ideas."*

Although this type of facilitation did occur during Study Two it was more prominent within this study as the design task was more complex than the previous study where the children were only required to understand two elements of the game.

Graph 6.1 shows that the children within the ASD team 3, who had not participated in Study Two, required slightly more support from the adults in terms of helping to facilitate their understanding of the design task. However, the two teams that had participated in the previous study only required marginally less support in this area and TD team 3, who also had not participated in Study Two required a lower level of support, so a lack of previous experience in this type of task was not necessarily a disadvantage in terms of task understanding.

The children from the TD teams were more likely to directly ask for help, with 46%-56% of the facilitation support provided by the adults within these teams resulting from a child's question. In contrast 28% of the facilitation support provided within ASD team 2 and 37% of the facilitation support provided within ASD team 3 was a direct result of a child asking for help. Therefore it was more important within these teams that the adults were aware of what the children were doing and could recognise any difficulties with understanding the design task or generating suitable ideas. This indicates a need to involve adult that is able to recognise the ASD characteristics of particular children.

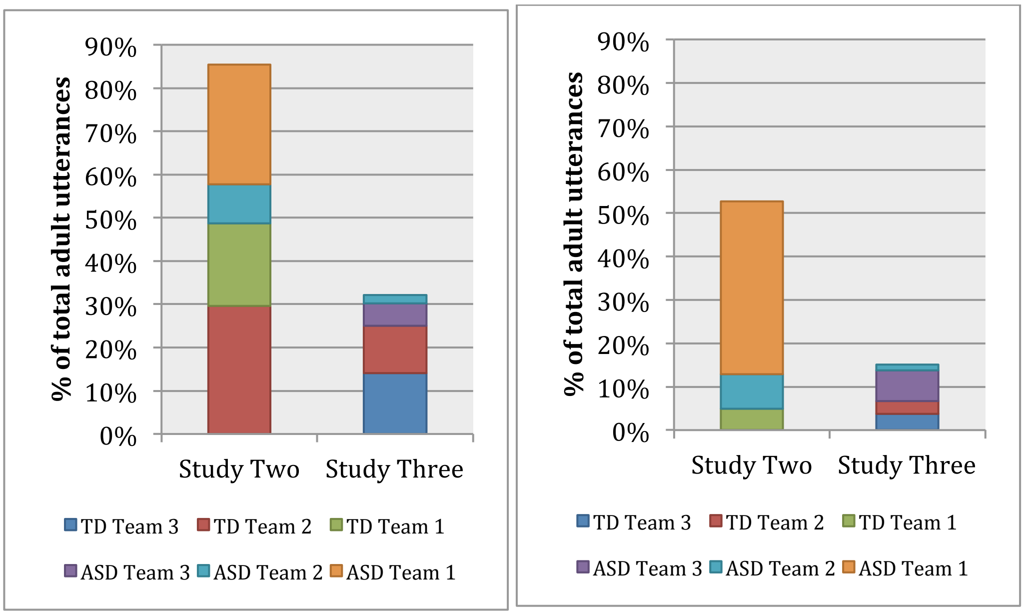


Graph 6.1 – Percentage of total adult utterances for providing different types of support during session three

As with Study Two the adults also provided motivational support through praise and encouragement, as well as directly prompting individual children to contribute ideas. However, as Graph 6.2 illustrates the level of motivational support and direct prompting was substantially reduced within Study Three. It could be predicted that the two teams which participated in both studies (ASD team 2 and TD team 2) would see a fall in the level of support required during idea generation as they would already have prior experience of this activity. ASD team 3 required a similar level of direct prompting as ASD team 2 did within Study Two, but substantially less than ASD team 1. They also required less motivational support than both ASD team 1 and 2 did during Study Two.

The paper templates helped to guide the discussion of ideas, with all children able to generate ideas for each of the different game elements and willing to discuss these ideas. Only some gentle prompting was required to ensure all team member got the opportunity to share these ideas. The discussion was semi-structured, with each game element discussed in turn, but no set format to the order participants could share their ideas. This allowed the more confident children to share their ideas first and the children less sure about their ideas to build on these initial ideas or share ideas later when they felt more confident. The adults directly prompted the quieter children to provide an opening in the discussion for them to share their ideas if they wished, but no child was forced to share ideas for every single game element.

There was also less motivational support required in comparison to Study Two, as less time was spent on each aspect of the game it was easier to maintain the children's engagement. With less distractions and a faster pace it meant that if the children struggled or were less interested in one particular element they could move onto the next element quickly helping to keep the activities flowing. These findings reveal an increased requirement for adult facilitation within more complex design activities, but that the provision of increased structure with the activities may help to reduce the level of prompting and motivational support that is required.



Graph 6.2 – Percentage of utterances that were either motivational statements (left) or direct prompts (right) used during session three in Studies Two and Three

6.4.1.2 Support for Documenting Ideas

Within the ASD teams the children both wrote and drew their ideas on the templates. One child within ASD team 2 who had dyslexia was unable to write many of his ideas, but was able to draw images both within the boxes and on the example game screenshot in the centre of the template. Although it would have been difficult for an adult to interpret these ideas, but only looking at the template, he was able to explain his ideas verbally using the template as a prompt. Some of the children within both of the ASD teams also tried to discuss their ideas verbally during the initial idea generation activity. They were reminded by an adult to firstly write or draw these ideas and then they would have the chance to verbally expand on these ideas at the end. This was to allow the other children time to think about their own ideas first without being distracted by another child's ideas.

Although some of the children required additional explanation before commencing their idea generation none of the children needed adult support to document their ideas. They were also all able to document multiple ideas for each game element. An issue that occurred within both of the ASD teams was the different speeds that the children worked at, with some children filling in every single box on the ideas template in the same time it took another child to generate one idea. They would then have to wait for the other child to finish, often distracting them further by talking. This was at times frustrating for both children; therefore it may be necessary to provide additional activities for the faster children to allow the other children the necessary time to complete their own idea generation.

Within the TD teams the children also used a combination of writing and drawing to document their ideas on the templates. The TD children were all able to document their ideas without any adult support. Although some children did work quicker than others, the faster children were able to wait quietly and patiently for the others to finish, and there was also less discrepancy between the idea generation speeds. There was one issue that occurred across all teams (both ASD and TD), which was the overlap in ideas between different game elements. For example between rewards and feedback, where some children were concerned they had documented the ideas on the wrong template. Therefore it was important for an adult to make it clear that these templates were solely being used to prompt idea generation and guide discussion, and it was perfectly acceptable to repeat ideas on different templates.

These findings highlight fewer issues with the documentation of ideas than within Study Two, as the children were all able to document their ideas with less adult intervention in the process. The templates used within Study Three explicitly encouraged multiple forms of idea expression, allowing as little or as much detail to be documented as needed to help guide the later discussions. There were some issues with several children wanting to share initial ideas verbally and also with the pacing of the idea generation within the team. However, the adults were able to manage these issues and the short bursts of idea generation ensured that it was easier to maintain engagement within the task and no child fell too far behind.

6.4.2 Appropriateness and Originality of Ideas

This section addressed the sub-research question **RQ1b) Are children with ASD able to generate design ideas, which are both appropriate and demonstrate some level of originality?** During Study Two it was found that the children with ASD were able to generate both appropriate design ideas that fulfilled the initial design brief and also generate design ideas that exhibited originality. To further explore these findings within a more open design space, the individual design outputs from the idea generation activity during session three were analysed. Firstly for each of the six game elements (Theme, Characters, Reward, Feedback, Sound, Maths Topic) the ideas generated by the children were considered to establish if each design idea was appropriate within the context of the individual game element template it was documented upon. An idea was deemed *appropriate* if it matched the game element category specified on the template the idea was documented upon and also fitted in with the overall design brief to design a maths game. Each of the children's ideas documented within the boxes on the six different templates (e.g. Fig. 6.5) was considered in turn using the criteria specified above and marked as appropriate if it met this criteria.

It was found that all of the children were able to generate at least one appropriate design idea for each of the game elements with the exception of all three children with TD team 2 and M4 from ASD team 2. The TD children struggled with specifying specific maths topics that could be included within the game. They concentrated instead on the integration of maths within the game and the feedback given for getting the answer correct and incorrect. This misunderstanding still persisted during the verbal discussion and the adult teacher who was participating within that team had to provide some appropriate examples to help the children understand the type of ideas that were being sought for this game element.

M3 from ASD team 2 also exhibited difficulty with generating ideas for the maths topic, with his only appropriate idea being "adding stuff" and again focusing on the integration of the maths within the game, rather than the specific maths topics. M4 struggled to generate appropriate ideas for a game theme, stating instead specific graphical elements that could be included within the game. A theme idea (the general topic of the game) is less concrete than some of the other game elements and therefore it is possible that this is why it was more difficult for M4 to comprehend. Overall it was found that there was a variability in the children's interpretation of theme ideas across both ASD and TD teams, with some children stating where the game would be set, some children stating the activity/goal of the game and some children suggesting game titles. However, all of the design idea types contributed to the establishment of a game theme in some way and so were deemed to be appropriate.

There were also differences in the connections between the children's ideas across the game elements; some children connected their ideas for some of the latter game elements with their original theme ideas whereas other children generated entirely unconnected ideas. This occurred across both the ASD and TD teams with differing results. Both TD teams chose to take forward one of these connected ideas, taking the core game idea from one child. This happened to a certain extent within the ASD teams, with one of the more fully formed game ideas being chosen. However, ideas from other children were also incorporated even if they did not appear to fit within the chosen theme resulting in a more disjointed game. This indicates a concern for the inclusion of ideas over the quality of the final output.

In contrast to Study Two the teams were not provided with an existing game as a starting point, but rather a basic platform level that had one character, a simple background and no other game elements. Therefore the children had the opportunity to generate original features within all game element categories, which they were all able to do. Within both the ASD and TD teams some of the children's ideas were based on existing computer games or TV programmes. However, these children were able to build on the ideas based on these existing games/programmes and generate further original ideas, which provided a useful way of inspiring the idea generation process.

6.4.3 Educational Technology Design Implications

This section addresses the sub-research question **RQ1c) What specific implications do these design ideas have for designing educational technology aimed at an ASD population?** To explore this research question a thematic analysis of the collectively agreed team game element ideas (from session three) and the final maths game prototypes was undertaken. This analysis was guided by the technology design principles initially presented in Chapter Two. As with the previous studies the results of this analysis are then discussed in terms of their implications for each of the high-level design principle categories and specifically for the design of educational technology for children with ASD. Similar concerns to Study One were recognised again within this study. Due to that the fact that the child participants had to build the game themselves, this may impact the game elements that were able to be implemented and therefore may not be a true reflection of the children's preferences. Therefore this analysis additionally encompassed the team's originally agreed collective ideas from session three. It should also be highlighted that at the end of the fifth session the children explained any remaining game elements that they had been unable to implement to an adult researcher who incorporated these additional ideas into the game before the final session. It is hoped that in conjunction with the findings from Study Two this should help to provide a useful set of principles for designers of technology aimed at children with ASD.

6.4.3.1 Visual Design

Animation and Sounds

Animation/Sound feature	ASD teams	TD teams
Animated game characters	✓	✓
Animated background elements	✓	
'Pop' sound effect to indicate game element appearing	✓	✓
Sound effects to highlight movement of game elements	✓	✓
Fanfare to indicate completion of level	✓	
Realistic sound effects	✓	✓
Background music	✓	✓

Table 6.3 – Animation and sound preferences of ASD and TD teams

The games designed and built by ASD team 2 and both TD teams incorporated an animated character that represented the player and could move around the screen. ASD team 2 also had background game elements continuously animated as the player played the game. However, in contrast the player character was static within ASD team 3's game, as well as all the other characters within the game, except during the provision of feedback. This approach could be more helpful in allowing the player to focus on the maths within the game, although it may decrease the 'fun' element of the game. It can be a difficult balance to achieve, but these findings show a variety of preferences in terms of animation use making it a difficult principle to generalise.

Both ASD teams and TD team 3 incorporated sound into their games, with all teams using a 'pop' sound effect to highlight the appearance or disappearance of certain game elements. ASD team 2 and TD team 3 also used sound to highlight the movement of game elements. Furthermore, ASD team 3 and TD team 3 chose to use some realistic sound effects within their games. Both ASD teams preferred to include a fanfare sound effect to indicate the completion of a level and all teams except for TD team 2 incorporated background music into their games, which was all non-lyrical. The use of sound seemed to be particularly important to the children with ASD who spent a long time listening and selecting different sound effects and music tracks available within Scratch during the build of their game. This highlights the importance of using sound within educational technology to help increase its' appeal. Although it is still important to bear in mind that children with ASD can be sensitive to some sounds and to provide control over this element of the game.

Colour and Graphics

Colour/Graphical features	**ASD teams**	**TD teams**
Bright colours	✓	✓
Irrelevant graphics	✓	
Realistic graphics	✓	
Uncluttered interface	✓	

Table 6.4 – Colour and graphical preferences of ASD and TD teams

All of the teams chose to make their games very colourful, although colour was not used in this instance to indicate anything specific within the game.

Both ASD teams had a tendency to incorporate graphics within their games, which were unrelated to the central theme of their game. Within ASD team 2 one of the boys did not mind what their game was like as long as it included "olives and grass", which had to be worked into the businessman/city-based theme idea generated by the other boy. Additionally, within ASD team 3 one boy wanted to incorporate a hill figure background within their futuristic robot-builder game, as hill figures were one of his special interest areas. The tendency of children with ASD to have obsessional interest areas can result in unrelated and irrelevant features being incorporated into their design ideas. Although the other children within the design teams were happy to accept these suggestions, due to the narrow areas these interests can fall within there is a reduced likelihood of wider appeal. Therefore the ability to customise certain features, such as the graphics, may be particularly important for an ASD population.

Both ASD teams also incorporated backgrounds that were based on real world places, whereas the TD teams games were set in more fantasy-based scenarios. Realism is a recurring theme within the preferences of children with ASD, and was similarly highlighted within Study Two, which could be due to their difficulty with abstract concepts and pretend play. Therefore real world based educational technology may be preferable for an ASD population. Again the concern about cluttering the interface design with too many elements was raised within ASD team 2, and was also expressed within Study Two.

Text

All of the teams included some text within their games, with ASD team 3 and TD team 2 including some limited text commands within their maths questions. ASD team 2 incorporated wordy maths questions, which required more advanced reading skills to be able to interpret them. Both ASD and TD teams also included some basic text-based feedback relating to answering the maths questions correctly or incorrectly as well as for completing the level.

None of this text was spoken, indicating that perhaps the child participants would not all experience difficulties reading this level of text. However, one boy within ASD team 2 had dyslexia and struggled with both reading and writing to an extent that he would be unable to read the maths questions incorporated into their game. As he also struggled with maths, this element was left to the other boy to implement who did not take into account the ability of his team member when deciding on the maths questions to include. Therefore it would be important to still incorporate spoken support for any text within educational technology aimed at an ASD population.

Age appropriate materials

There were no issues within any age inappropriate content incorporated into the games designed and built during Study Three, which indicates that it is possible to design educational technology that is both appealing and age appropriate for this population.

6.4.3.2 Feedback and Guidance

Task Structure and Control

The children were provided with a platform-based game as a starting point, which was less structured than the game within Study Two and enabled the player to explore the game environment by moving between screens. Although three of the teams kept this level of structure, ASD team 3 increased the structure within their game. This involved making the player character static and only allowing the player to input answers to the maths questions, removing any ability to move the character around the screen. This indicates a potential preference for highly structured educational technology and reflects a general preference for structured environments within the ASD population, following design principle 2.1.

Feedback

Feedback mechanism	**ASD teams**	**TD teams**
Text-based	✓	✓
Animation-based feedback	✓	✓
Penalties e.g. lose lives, money	✓	✓
Sound-based	✓	✓
Points-based	✓	✓
Reflective feedback		✓
Critical feedback	?	

Table 6.5 – Feedback preferences of ASD and TD teams

As in Study Two a variety of different feedback mechanisms were used within all of the teams' games including text, animations and sound effects. The ASD teams only used text feedback for incorrect answers, as did TD team 3, with feedback about correct answers being shown through animations and sound (e.g. gaining a robot part, rocks moving out of the way, money sound effect). Additionally within ASD team 2 feedback was shown through gaining and losing money. Although none of the other teams implemented a similar feedback mechanism, TD team 3 had planned to include a scoring system within their game. TD team 3 also wanted to enable the player to reflect upon their progress at the end of the level, by providing a breakdown of the player's correct/incorrect answers to the maths questions, highlighting the areas they need to improve. Reflection on performance was not something that was considered by either of the ASD teams.

Finally although all of the feedback eventually incorporated into the games was positive/encouraging, one boy within ASD team 3 had expressed a wish to include feedback that shouted at and insulted the player. This again continued a similar theme that initially arose within Study Two related to some children with ASD preferring more critical feedback.

6.4.3.3 Motivation and Engagement

Fun Features and Rewards

Fun feature/Reward mechanism	ASD teams	TD teams
Upgrades	✓	✓
Bonus levels	✓	
Random features	✓	
Positive text	✓	✓
Animated ending		✓
Certificate	✓	
Statistics		✓
Leader board	✓	✓

Table 6.6 – Fun feature and reward-based preferences of ASD and TD teams

The ASD teams incorporated a number of 'fun' features into their games, including upgrades, bonus levels and random features. The children in both ASD teams seemed to find a certain amount of 'randomness' within their games to be motivating. This included the collection of olives within ASD team 2's game, which served no obvious purpose within the game and a bonus 'tizer head' for the robot included within ASD team 3's game. These random features appeared to have a common significance for all of the children within the ASD teams, which may be due to the fact they were all classmates and were related to topics that had been discussed previously. These features may be meaningless to other children with ASD, but incorporating some essence of 'randomness' may still be an appealing feature for children with ASD in general.

The TD teams incorporated fewer additional 'fun' features, appearing to spend more time focused on the educational element of their games, indicating that children with ASD may need more motivational features than TD children within educational technology. Although the children within TD team 3 did discuss the ability to upgrade the player character.

In terms of the reward scheme all of the teams incorporated some positive text at the end of each level, which included phrases such as "*Well Done! Level Complete*" and "*Well Done! You're a maths genius*". TD team 2 also incorporated an animated ending to their level and wanted to provide some statistics about the player's performance on that level. ASD team 2 suggested providing the player with a certificate of their achievements and also including a leader board (as did TD team 2) so they could compare their achievements against other players. These reward mechanisms also featured within the preferences from Study Two, reinforcing the rewarding nature of these mechanisms.

Personalisation

Within this study little was discussed about the ability to personalise any of the game features, with the exception of ASD team 2 who suggested that the characters within the game could be customised. As previously mentioned there is a possibility that because the child participants are designing to their own preferences, they may not consider the need to provide personalisation options for others who do not share these preferences. It is difficult to establish whether the children within ASD team 2 did actually consider others within their design or were instead wanting to be able to adapt their own experience, for instance if they played the game multiple times.

6.4.3.4 Participant Children's Final Game Evaluation

The child participants completed a survey related to their final maths game during session six, to establish if they had been able to design and build a game that fulfilled their initial expectations as well as ensure that any outstanding game elements had been successfully communicated to and implemented by the adult researcher. This survey again incorporated a Smileyometer Likert scale (Read and MacFarlane, 2006) to determine the children's opinions of the overall game and also specific features of the game such as the look, sound and animation. Additionally within Study Three the final display of work activity (undertaken during session six) one of the templates was focused on the final game and required the children to jointly answer questions such as "what is good about the game?" and "what needs to be improved?". This was also included to provoke more discussion about the final game as the children may be reluctant to expand upon their opinions when asked to write them down within the survey.

In the Final Game survey all of the teams on average rated the specific game features as 'Really Good' or 'Brilliant', with the exception of the children in ASD team 2 who rated the game look as 'Good' and one boy within ASD team 3 who rated the game look 'Not Very Good/Good'. The teams all rated their game overall as 'Really Good' or 'Brilliant', again with the exception of TD team 2 who rated their game as 'Good'.

All of the TD children were happy that their final game was the way they wanted it to be, but the children with ASD were less sure with two children saying it maybe was the way they wanted and one child saying it definitely was not the way he wanted. The main concerns centred on the visual design of the game not being good enough, with one child from ASD team 3 saying it was "pixelated". The team also agreed during the display of work activity that it needed to be a proper platform game and one of the specific graphical elements needed to be more convincing. The children within ASD team 2 thought that the appearance of the game terrain needed to be improved and also that it could do with general "polish".

Some of the children also stated they wanted to change the questions to make them easier and to randomise them, as well as making the game longer with more levels. This indicates that the children may not have fully taken into account during their evaluation of the final product the fact the game was a prototype rather than a complete game. However, despite these concerns, all of the children with ASD would choose to play the game themselves and would recommend it to a friend as well.

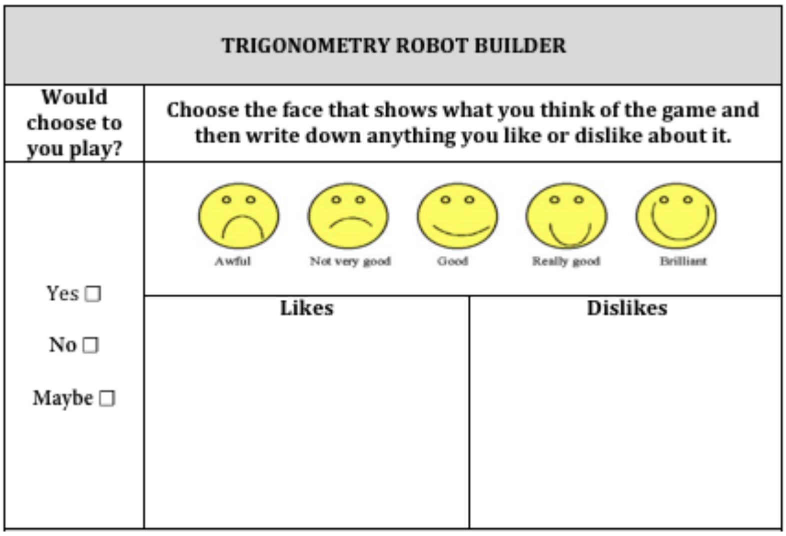
Finally the design teams that had taken part in Study Two were asked which of the two games they had designed they preferred. Whilst the TD children said the Study Three game or that they had no preference, both of the children with ASD said they preferred the original Study Two game. This may be due to the more ‘polished’ look of their original game, which was built by a technically skilled researcher who was able to spend many more hours on the build than the time available during the design sessions within Study Three, and is one advantage of having an adult undertake the build.

6.4.4 Appeal of Design Contributions

6.4.4.1 Design Contribution Evaluation Methodology

This section addresses the sub-research question **RQ1d) Do the design ideas appeal to non-participant children within the children’s wider peer group?** After the completion of Study Three the final prototype games were shown to the participant children’s wider peer group to establish the general appeal of the design outputs within their target audience. Twenty children with ASD (aged 10-15 years, average 13 years, 18 male/2 female) from ASD School 2 and 3 and 23 TD children (aged 12-13 years, average 13 years, 14 male/9 female) from Mainstream School 2 were shown the prototype maths games that each of the design teams had produced.

This evaluation activity was introduced to the TD children as a class, but was undertaken by the children individually. After each game was demonstrated the children were asked to complete a survey that incorporated a Smileyometer Likert scale (Read and MacFarlane, 2006), to find out whether they liked or disliked the game. They were also asked if they would choose to play the game and to write down any specific likes or dislikes (see Fig. 6.7). The children were then asked to complete a survey about their views on computer games in order to direct attention away from the prototype maths games.


TRIGONOMETRY ROBOT BUILDER

Would choose to you play?	Choose the face that shows what you think of the game and then write down anything you like or dislike about it.	
Yes ☐ No ☐ Maybe ☐	Awful / Not very good / Good / Really good / Brilliant	
	Likes	Dislikes

Figure 6.7 – Example evaluation survey for one of the prototypes maths games

Lastly the children were asked to complete an evaluation activity based on the Fun Sorter, another instrument from the Fun Toolkit (Read and MacFarlane, 2006), which is used for ranking items. The children were instructed to rank the games based on firstly which game they would most like to play and secondly which game would be most helpful for learning maths. They were also asked to give reasons for the games they most/least liked and which ones they thought were the most/least helpful for learning maths (see Fig. 6.8). Screenshots of each of the games were displayed on the interactive whiteboard at the front of the class throughout this exercise to provide a visual prompt.

The children with ASD undertook the evaluation activity individually with an adult researcher, and again were not required to undertake the computer game opinion survey as the order they were shown the games was randomised. During the ranking activity the children were asked to place images of each of the games in the different boxes within the ranking template to indicate their chosen ranking order. The researcher noted down all of the children's answers for them.

Name:	**Best**	**>**	**>**	**Worst**
Which game did you like the most?	Space Brain	Me and the Sea	Calculator Board Sprint	Robot Builder
Why did you like/not like it?	It had a clear aim and would easily encourage children to learn			It had bad graphic and you dont know what your doing.
Which game was best for learning maths?	Me and the Sea	Space Brain	Calculator Board Sprint	Robot Builder
Why was it good/bad for this?	It questions had a big variety.			It wouldn't encourage children to learn

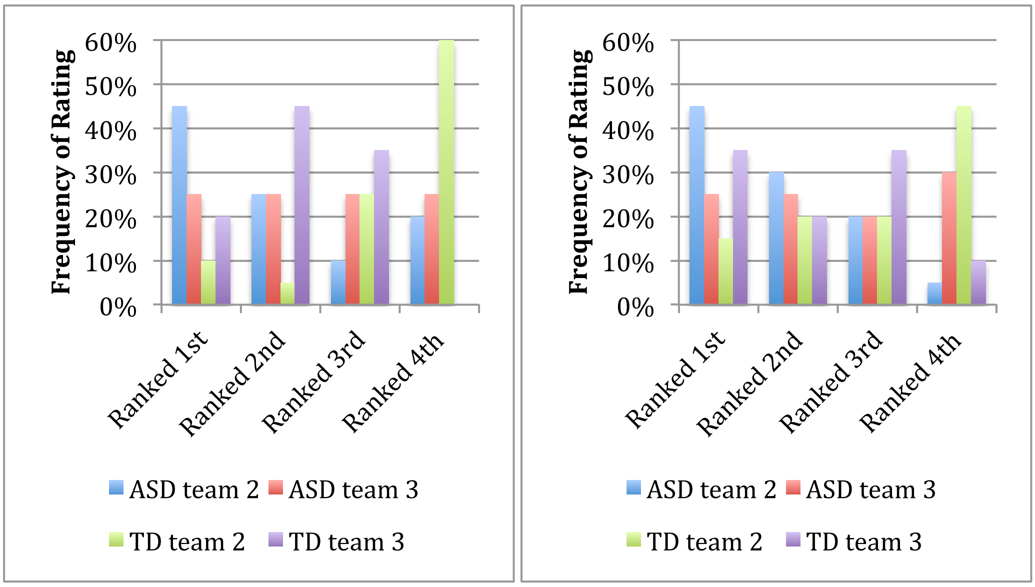
Figure 6.8 – Completed prototype game ranking sheet

6.4.4.2 Design Contribution Evaluation Findings

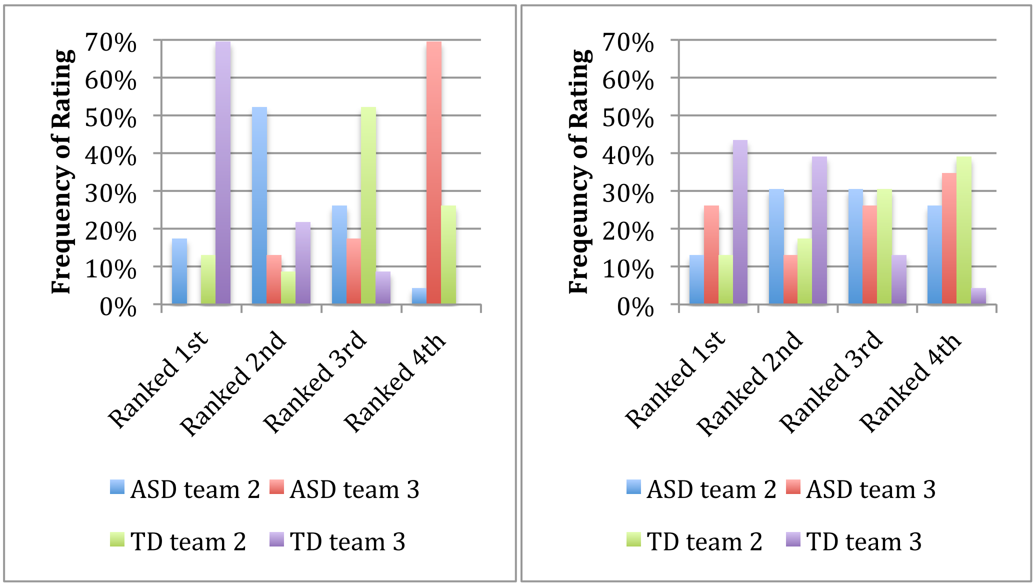
The findings from the evaluation survey showed that the ASD group had a preference for the game designed by ASD team 2 with 45% of the children ranking it as their best game and 45% of the ASD group also rated this game as the best for learning maths. The TD group showed a clear preference for the game designed by TD team 3 with 70% of the children ranking it as their best game and 45% of the children ranking it as best for learning maths. Graphs 6.3 and 6.4 show that both the games designed by ASD team 2 and TD team 3 were clearly preferred over the other two games by both groups of children. However, rankings for the best games for learning maths were more mixed within both groups. The ASD group ranked the game designed by TD team 2 as their least preferred game, with 60% of the children ranking it as their worst game and 45% of the children ranking it as the worst for helping to learn maths. The TD group again showed a clear consensus for their least preferred game, with 70% of the children ranking the game designed by ASD team 3 as the worst game. However, in contrast with the other results the TD group did not also rank this as the worst for helping to learn maths and instead 39% of the children ranked the game designed by TD team 2 as the worst.

Spearman's correlation shows there is a rank order relationship between the appeal of a game to children with ASD (Mdn = 3, IQR = 2-4) and the perceived ability of the game to help with learning maths (Mdn = 2, IQR = 1-3), which was $r=.342$ ($p<.05$). This result shows that making a game appealing could also potentially make it appear better for helping to learn maths. This further highlights the importance of the appeal of the game as if a game is unappealing this may negatively impact the maths learning. This was the same for the TD group where Spearman's correlation between the appeal of the game

(Mdn = 3, IQR = 1.75-3.25) and the maths learning (Mdn = 3, IQR = 2-4) was r=.511 (p<.05).



Graph 6.3 – ASD group rankings of prototype maths games for most liked game (left) and best game for learning maths (right)



Graph 6.4 – TD group rankings of prototype maths games for most liked game (left) and best game for learning maths (right)

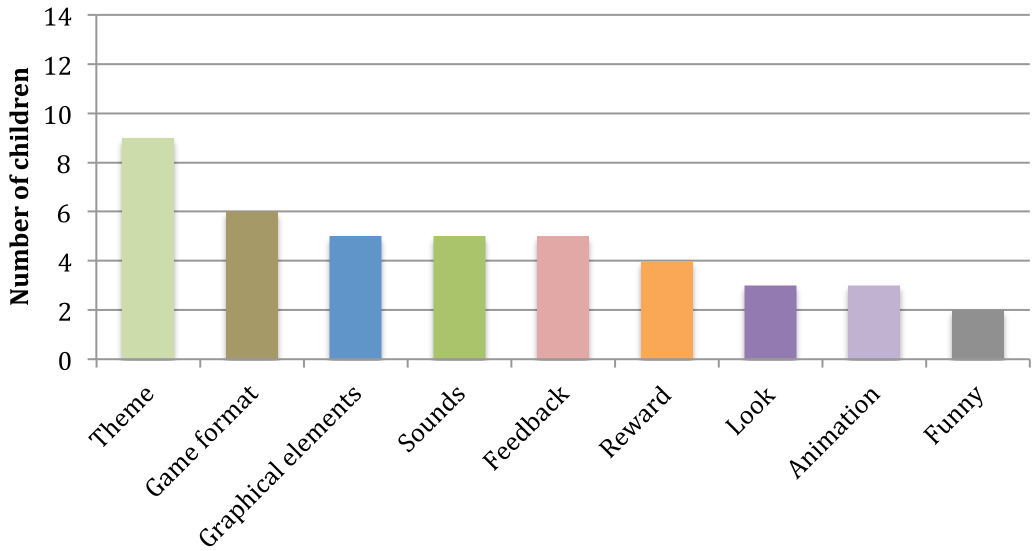
Graphs 6.4 again show there is a high agreement amongst the children within the TD group about which of the games were most appealing, with over half the children giving the same rank for each of the games. The agreement within the ASD group is less strong, although there was clear agreement relating to the appeal of three games, but opinion over the game designed by ASD team 3 was equally divided across all four rankings. There was much more variability in responses relating to which games were most helpful for learning maths within both groups, but as stated above the appeal of the game potentially had an impact on the perceived helpfulness of the game for learning maths.

Reasons for Liking

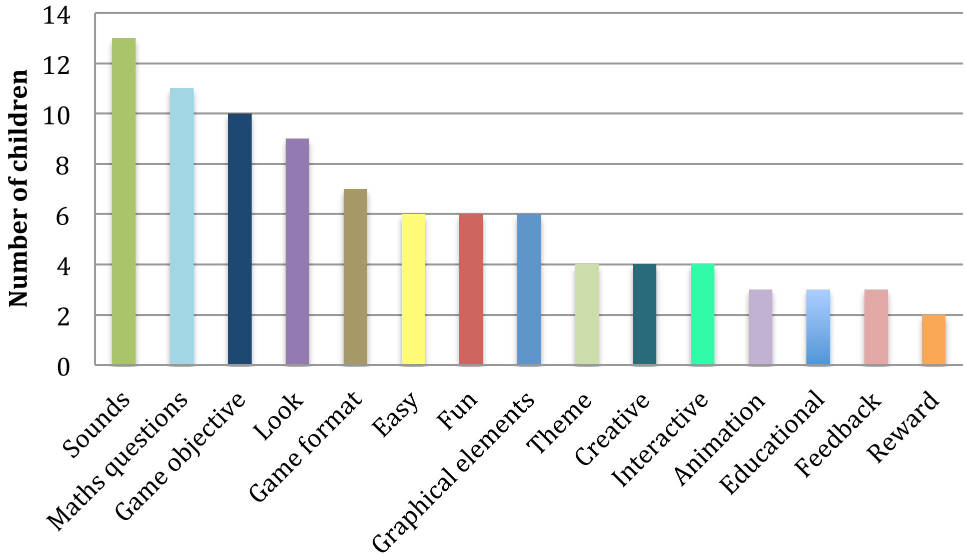
During the evaluation activity the children were asked to say what they liked/disliked about each of the games as well as provide reasons for high or low rankings. Graph 6.5 and 6.6 below provide an overview of the reasons given across all four prototype maths games for what the ASD and TD groups liked about a particular game. Overall the 46 separate reasons from the ASD group were grouped into 13 separate categories and the 93 separate reasons from the TD group were grouped into 16 separate categories. However, only the reasons given by two or more children have been included within the graphs as these reasons are more likely to offer insight into the preferences within their wider peer group. Firstly there is a large difference between the numbers of reasons given by the different groups, as the children from the TD group typically gave multiple reasons for liking a game. Whereas the children from the ASD group would frequently only provide a single reason for liking a game, with some children unable to provide a reason at all. This resulted in a wider spread of reasons within the TD group, although there was higher agreement in the most common responses, with the top three reasons specified by 10 or more children, whereas the highest agreement amongst the ASD group was nine children.

Graphs 6.5 and 6.6 show a clear difference between the most common reasons for liking a game between the ASD and TD groups. The ASD group expressed a preference for games because of the specific theme (such as it being set in space), specific things about the format of the games (such as the way the answer is inputted or the provision of multiple lives) as well as expressing a liking for particular graphical elements within the game. There was a commonality between the groups in terms of finding the sounds appealing, particularly the background music.

The children within the TD group considered the educational aspect of the games in their responses with many children finding a game appealing because they liked the style or type of maths questions. They also considered the overall appeal of the game in terms of the high-level game objective or the general appearance of the game. These preferences again show a difference between the groups reasons, with the children with ASD focusing on more specific features of the game whereas the TD children tended to consider the 'bigger picture' of the game, including the educational side.



Graph 6.5 –Reasons given by two or more children from ASD group for liking prototype maths games



Graph 6.6 – Reasons given by two or more children from TD group for liking prototype maths games

Reasons for High Ranking

Looking specifically at the reasons behind why the children from each group ranked a particular game as their most liked highlights the reasons considered most important by each of the groups. The most popular reason within the ASD group was because of specific graphical elements within the game with five children stating this as a reason. The look, theme and reward scheme were also stated as reasons each by two of the children with ASD. In relation to the most appealing game, which was designed by ASD team 2, the specific features the children liked about this were the businessman character, the olives that were collected, the business theme and the money-based reward scheme.

The TD group again gave more reasons for why they ranked a particular game the highest, with eight children saying it was because of the look of the game and seven children saying it was because the game seemed fun. However, in relation to the most appealing game, which was designed by TD team 3, they specified these reasons as well as a range of other reasons including the sounds, game objective, educational value, animation, game format and space theme.

These differences highlight the difficulty of designing a game that is appealing to a wide range of children with ASD, who appear to be more focused on specific graphical elements than the TD children. Therefore it is important to make these specific details appealing, as the children may not base their opinion on the overall game, but rather its' component parts.

Reasons for Helpfulness in Learning Maths

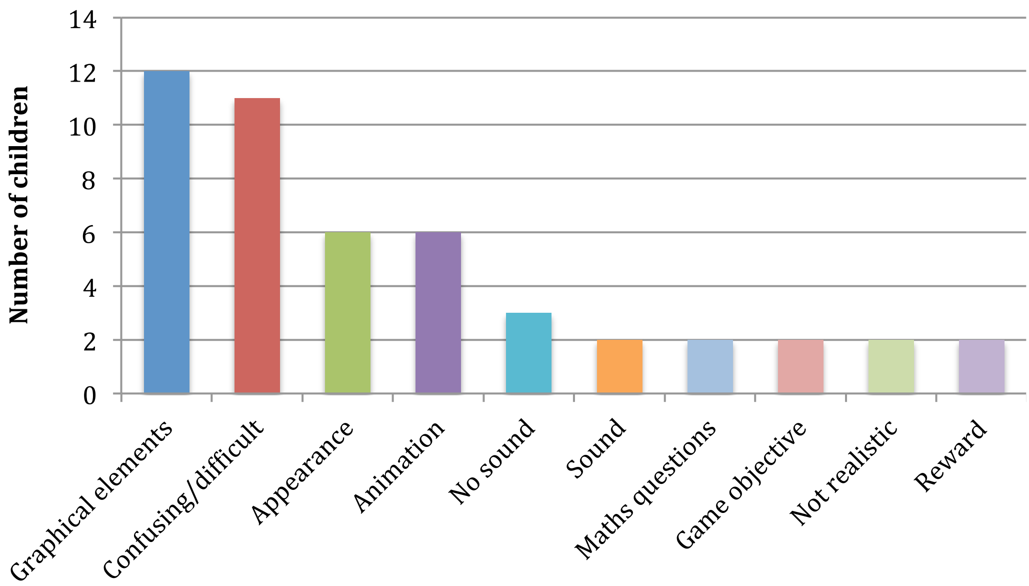
Within this study the children were additionally asked to rank the games according to which ones would be most helpful for learning maths, and again provide reasons for the ranking of the best and worst games. The ASD group provided a wider variety of reasons than the TD group, with the maximum number of children specifying the same reason being two. Several children with ASD struggled to answer this question, with some unable to provide a reason at all. Formulating a reason could be quite challenging for children with ASD as it requires them to reflect on their own potential learning, which is an abstract concept and something they can typically struggle with. However, the reasons specified by those children who were able to included the fact the maths questions were simple, the style of the maths questions, the way the questions were incorporated into the game and the game being encouraging to the player.

The children from the TD group found this question more straightforward than the ASD group and all children were able to provide a reason for why their highest ranked game was most helpful for learning maths. Similar to the ASD group, seven TD children also stated that the style of question used made it more helpful and four of the children stated that the game was encouraging to the player. Additionally five children stated both the greater variety of the questions and the higher number of questions made the game better for learning maths, and four children felt that the incorporation of more challenging questions was helpful. The higher difficulty of some questions was something only considered by one child with ASD, with other children thinking that easier questions would be more helpful in them learning maths, potentially due to the increased fear of failure within the ASD population. This indicates a need to carefully balance the level of difficulty within educational technology aimed at children with ASD.

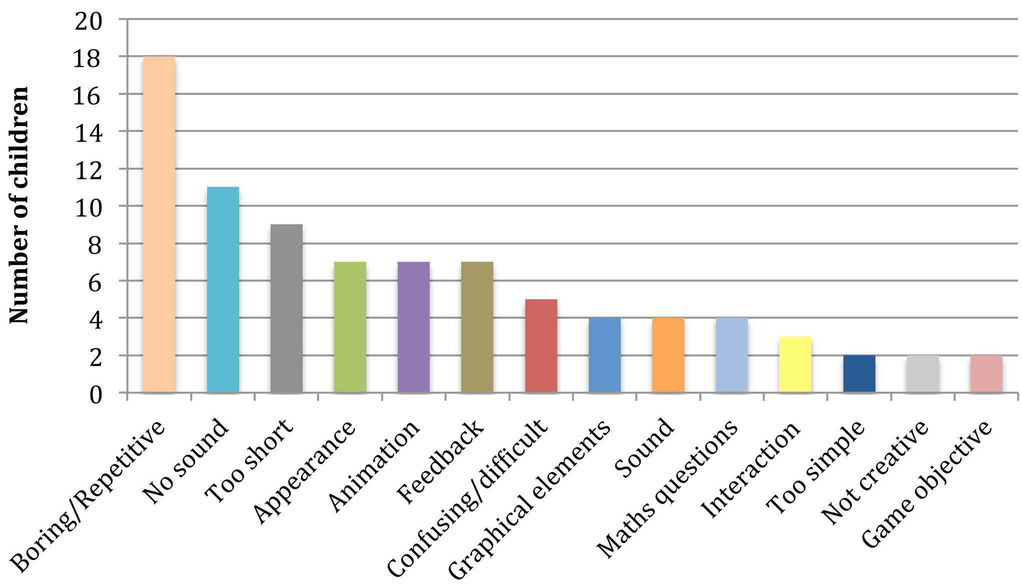
Reasons for Disliking

Graphs 6.7 and 6.8 below provide an overview of the reasons given across all of the prototype maths games for why the ASD and TD groups disliked particular games. Overall there were 52 separate reasons given by children in the ASD group (14 categories) and 91 separate reasons given by children in the TD group (20 categories), however again only the reasons given by two or more children have been included within the graphs. The TD children typically specified multiple reasons for disliking a game (although some children with ASD did also), but several children with ASD unable to provide a reason at all. There were two key reasons for the children from the ASD group disliking a game, which were due to specific graphical elements (12 children) such as the game characters or because they perceived the game to be confusing and/or difficult (11 children). This reflects the findings from Study Two where these were the two main reasons for the children within that study disliking the game, as well as due to a dislike for the theme and look of the game.

There was a clear difference between the ASD and TD groups. The TD children disliked a game if they perceived it to be boring or repetitive (18 children) with the lack of sound (11 children) and length of the game (9 children) also decreasing their opinion of the game. These reasons again reflect a consideration of the overall game within the TD group. It is clear that there is also the increased tendency within the ASD group to fear failure within the game than within the TD group.



Graph 6.7 – Reasons given by two or more children from ASD group for disliking prototype maths games



Graph 6.8 – Reasons given by two or more children from TD group for disliking prototype maths games

Reasons for Low Ranking

Looking specifically at the reasons behind why the children from each group ranked a particular game as their least liked highlights the elements of the game that are also important to get right to ensure the game is appealing. The most common reason for a game receiving the lowest ranking within the ASD group was because the children perceived the game to be confusing or difficult with four children stating this reason. The next most common reasons included a lack of or bad animation, a lack of sound and a dislike of the specific maths questions included. In relation to the least appealing game, which was designed by TD team 2, the specific features the children disliked about this was the main game character, the fact the game had no sound and some children also thought the maths questions were too difficult.

Within the TD group, as with Study Two, the most common reason for a game receiving a low ranking was because the children thought it was boring, with 11 children stating this reason. There were also some parallels with the ASD group, with the next most common reasons (each stated by four children) including finding the game difficult or confusing, a lack of or bad animation, a lack of sound and a dislike of the game format. In relation to the least appealing game, which was designed by ASD team 3, the specific elements of the game the children disliked were that the game was boring and repetitive, the fact the player character did not move and it was not very interactive, as well as that there was not much of a 'game', with the main focus being on just answering maths questions. These findings highlight that although the fun elements of an educational game are very important in increasing its' appeal, particularly for TD children, ensuring the level of difficulty can be adapted to the ability of the player is the top priority when designing a game aimed at children with ASD. This may mean starting at an easier level to build up the children's confidence and engagement within the game before progressing onto more challenging content.

Reasons for Unhelpfulness in Learning Maths

Finally with regard to the games that the children ranked as least helpful for learning maths again the most common reason given by the children from the ASD group was because they found the maths questions confusing or difficult, which was stated by six children. A number of children also gave other reasons that were not directly related to the maths content, and they suggested that the game not rewarding the player enough for doing well, having bad graphics, having distracting or irrelevant features as well as being boring (therefore not encouraging the player to engage with the maths) all affected the success of the game in helping the player to learn maths.

Many of the children from the TD group also believed that if a game was boring and did not encourage the player then this was not helpful for learning maths. They also gave other reasons for giving a low ranking for helping to learn maths, which included having too few maths questions within the level, a lack of variety in the maths questions and the questions being too easy. Again this reflects the greater ability of the TD children to reflect upon their own learning and also their increased willingness to attempt more challenging questions within the game. As children with ASD can struggle with failure achieving the correct balance of suitable maths content and appealing game elements that reward and encourage, but do not distract from the educational focus of the game, is an key goal for technology designers.

6.5 Summary of Design Contribution Findings from Study Three

This chapter has described the refinements made to the IDEAS method for use during a collaborative design *and build* task. It has also discussed the design contribution findings from Study Three, which involved four design teams who followed this further refined version of the IDEAS method. The key findings from this chapter are summarised below, presented under each of the sub-research questions that guided the analysis.

6.5.1 Relevance to Research Questions

RQ1a) Do children with ASD require any form of support in order to generate and/or communicate their design ideas?

The analysis of the support required for the idea generation activities highlighted that overall the children within Study Three required less prompting or motivational support than Study Two. This is partly due to two teams having participated in the previous study and therefore needing less support due to their familiarity with the activity. However, the level of prompting and motivational support was also relatively low within the new design teams, which indicates that the restructuring of the idea templates may have also reduced the need for constant adult intervention within the idea generation process.

It was found that the children with ASD required more adult support to facilitate their understanding of the design task, potentially due to the added complexity within this study, but that they were less likely to explicitly ask for this additional support. This highlights the need for the adults to maintain an on-going awareness of the children's progress within each activity and to intervene if the child exhibits any signs of experiencing difficulty with the task. This issue is discussed further within the following chapter in terms of the adult's role within this process. There was also a clear difference in the levels of support required by the existing ASD team (ASD team 2) and the newly formed ASD team (ASD team 3), with ASD team 3 requiring more support in across all categories. This indicates that within ASD team 2 the children's contributions may have evolved from the earlier study and participating over an extended period of time could potentially enable children with ASD to develop their idea generation abilities.

The need for adult support for documenting ideas was also reduced within this study compared to Study Two, with all the children able to document their own ideas without adult intervention. There was a greater variation in ability and working pace within the ASD team and the children with ASD were also less aware or less tolerant of having to wait for other team members to finish generating ideas than the TD children. This is explored further within Chapter Eight, in relation to the children's ability to collaborate. This could be explained by a lack of empathy as predicted by the ToM and E-S theories (Baron-Cohen, 2000b, Baron-Cohen, 2009) and the ability to recognise that other children may need more time than them to generate ideas. This highlights a need for the IDEAS method to be further tailored based on ability within these activities and to ensure children are occupied with additional activities to prevent them from distracting other children from completing a core design activity.

RQ1b) Are children with ASD able to generate design ideas, which are both appropriate and demonstrate some level of originality?

The analysis of the appropriateness and originality of the children's design ideas for each game element generally supported the findings from Study Two that the children were able to generate ideas that fulfilled the design brief and demonstrated some originality. However, the findings indicated a potential issue with some children with ASD struggling to understand more abstract game elements, which may mean more examples need to be provided to ensure comprehension of any abstract elements of the design to prevent inappropriate ideas being generated.

There were also issues within the ASD teams with connecting ideas from multiple children to a central theme in order to produce a coherent game narrative. This resulted in the inclusion of irrelevant features, which may potentially confuse players of the game. This was not true of the children within the TD teams who based their game predominantly one child's game concept and built on this by incorporating further ideas guided by this central concept. This contrast with the ASD teams could be due to a tendency of children with ASD to focus on the finer details and difficulties in seeing the 'bigger picture' as stated by the WCC theory (Happé and Frith, 2006), meaning that the children were not able to recognise that these features did not fit into the overall game.

RQ1c) What specific implications do these design ideas have for designing educational technology aimed at an ASD population?

In terms of implications for educational technology design, the analysis of the paper-based team interface design template and final prototype maths games again highlighted the importance of realistic graphics. They also revealed a common desire to include very specific graphical elements, often related to the special interests of the children. The incorporation of sound was also important, with both ASD teams using sound to highlight certain events within the game and both teams also spending a large amount of time on their choices of background music and sound effects. This again highlights the importance of getting this choice right and the need to give the user control over this choice as preferences may vary across the ASD population due to individual differences and specific sensitivities. Finally the children with ASD included more 'fun' features within their game than the TD children, and many of these features were unrelated to the game theme or maths content and initially appeared to be quite random. However, they had meaning for all of the children within the team due to shared previous experiences, and may have been something that would be difficult for an adult technology designer to interpret if the children had not also been included within the build phase.

These random fun features along with the very specific choice of graphical elements could be a result of the narrow obsessional interests of the children with ASD, due to difficulty in switching attention as predicted by the ED theory (Ozonoff et al., 1991) or a drive to understand 'systems' as predicted by the E-S theory (Baron-Cohen, 2009) and is an issue that was also raised during Study Two. This provides further evidence for the need to incorporate customisable elements within educational technology, due to the reduced likelihood of commonality between these narrow interests within the target ASD population.

RQ1d) Do these design ideas appeal to other children within the ASD population?
The analysis of the results to determine the appeal of the prototype games across the children's wider peer groups again revealed a clear difference in the preferences of the ASD and TD groups. The ASD group preferred a maths game designed by one of the ASD teams and the TD group preferred a maths game designed by one of the TD teams. This was in contrast to Study Two, where the ASD group preferred a maths game designed by one of the TD teams. This indicates that allowing the children with ASD the opportunity to also build the game themselves may have helped to increase the game's appeal amongst their wider peer group. It was also found that there was a correlation between the appeal of the maths game with the potential helpfulness of the game for the child's maths learning. This highlights the importance of the overall appeal of the technology in relation to the potential to positively impact a child's learning.

The results again reflect a similar pattern to the preferences shown in Study One and Study Two, with the ASD group focusing on more specific features of the game when providing reasons for why a particular game was appealing. They also rarely considered the educational value of the game within the assessment, which many children from the TD group did. Again this could be explained by a tendency to focus on the finer details as predicted by the WCC theory (Happé and Frith, 2006) or their drive to understand systems by focusing on the individual components as predicted by the E-S theory (Baron-Cohen, 2009), highlighting the importance of getting the details right.

This study specifically focused on the potential ability of the games to help with maths learning. It was found that the children with ASD found the games with more difficult or confusing maths content to be more unappealing and less helpful to their maths learning, preferring more straightforward simple games. This preference could stem from a fear of failure often observed in individuals with ASD and also a need for sameness and predictability, as when answering simple maths questions that they have seen before they will know what the correct answer is, rather than being less sure about more challenging questions. This is something predicted by the E-S theory (Baron-Cohen, 2009), due to a drive to systemise and keep everything constant in order to systemise more successfully. Again a liking for specific elements and increased sensitivity to the level of the maths content, highlights the importance for technology designers to ensure they themselves focus on the details when developing educational technology for an ASD population.

Also to incorporate options to allow the technology to be individually customised to the children's specific preferences and ability level.

6.5.2 Summary

The findings from this study indicated that integrating additional support for idea generation into the activity in the form of paper templates might help to reduce to the need for high levels of adult intervention. However, they also highlighted a need for the adults to continue to maintain an on-going awareness of the children's understanding of the design task to prevent any difficulties or confusion. The findings identified the requirement for additional activities to be provided to reduce the distractibility of the higher ability children as well as the provision of examples for more abstract design elements and support for enabling the children to develop ideas that follow a coherent theme. The comparison of the new and existing design teams revealed the possible benefit of having previous experience in these types of tasks with regard to idea generation ability.

The findings from the evaluation of the final games suggested that involving children with ASD in the build of the prototype could potentially increase its' appeal to the children's wider peer group. The ideas generated by the participant children and opinions shared by the non-participant children again highlighted the importance of carefully considering the finer details of a new technology. They also highlighted a need to provide control over certain elements of technology to customise them to the children's particular preferences and/or sensitivities, in line with the findings from previous chapters, as well as ability level to mitigate concerns over failure.

The last two chapters have established the ability of children with ASD to successfully generate design ideas within a collaborative design environment that appeal to their wider peer group. The next section will explore the children's experience of participating within the technology design process in more depth and will also consider if they benefited from this participation in any way.

Chapter 7 Participating within a Design Team

7.1 Introduction

This chapter builds on the *participation* findings from Study One, discussed in Chapter Four, in respect to **RQ2) To what degree can children with ASD participate in the design of technology and taking account of existing theories of autism, how do *existing design methods* need to be adapted to enable this participation?** This research question was initially examined during Study One with children on an individual basis participating in a one-off design sessions. There were several participation-related findings from this study, which could have an influence on the participation of children with ASD within the technology design process. These findings include a need:

- For the adult undertaking a number of different roles to support the children's participation.
- To involve adults with different knowledge in the fields of technology and autism as well as knowledge about the child participants' individual characteristics.
- To find other ways to reduce the reliance on a high level of verbal prompts and to allow the adults to undertake the activity with the child as a participant within the process, generating their own ideas and expanding upon the children's ideas.
- To provide different modes of expression for the children to share their ideas including drawing, writing and verbal explanations.
- To show ideas in a concrete way, demonstrating a clear link between the paper and computer-based prototypes.
- To undertake the sessions in a distraction-free environment and to provide time to build up relationships within the team.
- To be able to tailor the sessions to the specific needs and preferences of the participants, as well as allowing "on the fly" tailoring with the adult undertaking a flexible role and adapting the level of assistance they provide to the requirements of the individual children.

Studies Two and Three widened the scope of **RQ2** to include participation within a design team over an extended period of time. They also explicitly consider the benefit that participation in the technology design process can have for the children. The above findings from Study One were taken into account during the planning of the following studies and the IDEAS method was adapted accordingly. Study Three further builds on the participation opportunities by allowing the children to additionally participate within the build phase of the prototype and to determine the list of tasks to be completed for these build sessions.

7.1.1 Outputs and Analysis

In order to address **RQ2** within the context of a collaborative design environment the outputs from Studies Two and Three were analysed separately but following the same process (see Table 7.1). The analysis of each output has been guided by a series of sub-research questions, which are noted within Table 7.1 and discussed in further detail below. The participation of the children with ASD during the technology design process is considered with regard to i) the role of the adult participants, ii) the level of the children's engagement within the session and iii) the benefits of this participation. Each of these aspects is initially considered through the analysis of the findings from Study Two and then further explored to establish the impact of increasing this level of participation through the findings from Study Three.

Output	**Sub-Research Question**
Digital videos of Sessions Three, Four and Five from Study Two	RQ2a
Digital videos of Sessions Three, Four and Five from Study Three	RQ2a
Completed Participation Experience survey from participant children from Study Two and Three	RQ2b
Completed Displays of Work from final session from Study Two and Three	RQ2b, RQ2c
Surveys completed by teaching staff members focused on benefits to participant children from Study Two and Three	RQ2c

Table 7.1 – Outputs of Study Two and Study Three and related sub-research questions

RQ2a) What role do adults need to play to best enable the participation of children with ASD within the technology design process?
To address this sub-research question the videos of sessions three, four and five from both studies were transcribed and the different roles undertaken by the adult participants defined. These roles were then used to identify the instances of adult participation within the session, through the coding of individual utterances, to determine the frequency of each role being undertaken and the transition between the different roles.

RQ2b) What are the most effective techniques for engaging children with ASD as active participants within the technology design process?
To address this sub-research question self-reported data from the participant children was examined, which included the surveys completed by the children relating to their opinions of participating in the sessions and the documented answers during the display of work activity relating to specific activities liked/disliked were analysed. This was done to establish which activities and resources most successfully and positively engaged the children within the sessions.

RQ2c) Does participating in the technology design process benefit children with ASD in any way?
To address this sub-research question the results of surveys completed by the teaching staff members who participated within each design team, were analysed to find out if they believed the children benefited from their participation and in what ways. The documented answers from the display of work activity within Study Three were also looked at to see if the teachers' responses corresponded with what the children believed they had gained from their participation.

The findings from this analysis are described in more detail below.

7.2 Role of the Adult

This section addresses the sub-research question **RQ2a) What role do adults need to play to best enable the participation of children with ASD within the technology design process?** As has been previously established when involving children with special needs, such as ASD, within the technology design process the role the adults undertake in supporting this participation is especially important, due to the additional difficulties the children may experience. Within the literature there has been more focus on the role of the children within the design process and the role of the adult is typically discussed in terms of facilitating the children's role or simply playing a role that is equivalent to that of the child participants. However, some researchers have referred to additional roles that the adults play when participating within a design team (Read et al., 2002, Guha et al., 2004, Nesset and Large, 2004, Guha et al., 2012).

The need to undertake several different roles was also highlighted during Study One. Within Study Two the roles employed by the adults during the design sessions and the implications for best enabling the participation of children with ASD was explored by analysing the videos from sessions three, four and five (the sessions focused on designing the maths game). In order to determine these roles, firstly literature detailing previous research involving design teams of children and adults was examined, and from this a number of different adult roles were identified. Table 7.2 collates these findings, providing a description of each role and the reference for the corresponding literature.

Role	Description	Corresponding Literature
Facilitator	Adult sets the agenda or the structure for the session, provides additional explanation, facilitates a consensus within the team, clarifies ideas/opinions or helps to enable progress in accordance with the research plan to facilitate the children's participation within the session.	(Guha et al., 2004, Nesset and Large, 2004, Guha et al., 2012)
Motivator	Adult provides praise or encouragement to help motivate the children's engagement within the session.	(Guha et al., 2004)
Caregiver	Adult maintains the children's wellbeing by providing support for any non-task related problems/issues the children have during the sessions and ensuring appropriate interactions between participants.	(Guha et al., 2012)
Participant	Adult contributes an idea or expands upon another participant's idea.	(Guha et al., 2004, Nesset and Large, 2004, Guha et al., 2012)
Prompt for Contribution	Adult explicitly prompts a child to contribute an idea or opinion.	Not currently defined in literature
Prompt for Behaviour	Adult explicitly prompts a child to maintain good behaviour.	Not currently defined in literature

Table 7.2 - Definitions of Adult Roles during the Technology Design Process

An *utterance* was considered to be a sentence or number of sentences spoken without any obvious pauses or interruptions by another team member. Each of the transcripts from sessions three, four and five, for all four teams, was examined and every utterance made by the two adult researchers and the teaching staff member within the team was coded using the role descriptions presented in Table 7.2. Each utterance could only be coded with a single role. During this process it was found that in addition to actively undertaking the more general roles highlighted within the literature, the adults would sometimes specifically prompt a child, either because they were not contributing to the session or they were behaving inappropriately. These instances were captured within the role descriptions through the definition of two new roles, *prompt for contribution* and *prompt for behaviour* (see Table 7.2). These two additional roles were also employed within the coding of the utterances during a second pass through the transcripts. Below are example utterances for each of the adult roles:

- Facilitator: [Researcher] "Ok, so if everyone can write their ideas down"
- Motivator: [Researcher] "Really good ideas there guys"
- Caregiver: [Teaching Staff Member] "So do you need your glasses?"
- Participant: [Child] - "How is it going to know I like magic?" [Teaching Staff Member] - "When you log in it could ask what you're into"
- Prompt for Contribution: [Researcher] "M4 do you want to go next?"
- Prompt for Behaviour: [Teaching Staff Member] "Come on guys, let's stay on task"

It is also important to note that some utterances made by the adults, such as one word statements e.g. "ok", passing remarks or social conversation unrelated to the task as well as passive support such as smiles or nods, where the adults were not actively undertaking an identifiable and meaningful role within the session were considered to be outside of the scope of this particular analysis and were therefore not coded.

In order to validate the reliability of this coding scheme, a second independent person (who had not participated in the sessions or been involved in the development of the coding scheme) also used the coding scheme to code a representative subset of the sessions. This included two separate sessions; one session involving a TD team from Study Two and one session involving an ASD team from Study Three to ensure the full range of the codes could be validated. Due to ethical and confidentiality considerations the second coder was not able to view the actual videos of the sessions and therefore worked solely from the transcripts. The percentage agreement between the two coders was 92%. The inter-coder reliability was then calculated using Cohen's kappa, with a value of 0.795. Banerjee et al. (1999) provide a criteria for Cohen's kappa, which states that any value >0.75 is excellent agreement beyond chance, thus the above coding scheme could be deemed to be reliable.

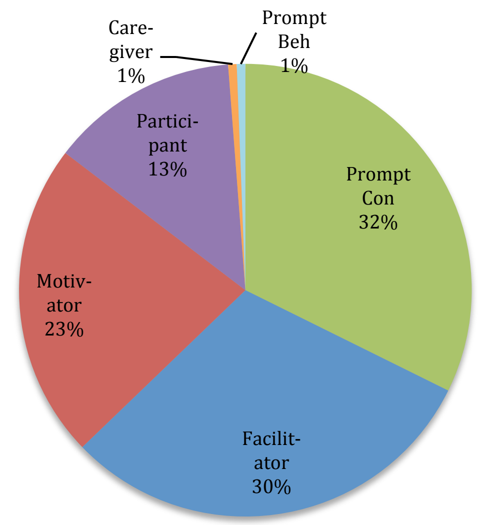
7.2.1 Study Two Adult Role Findings

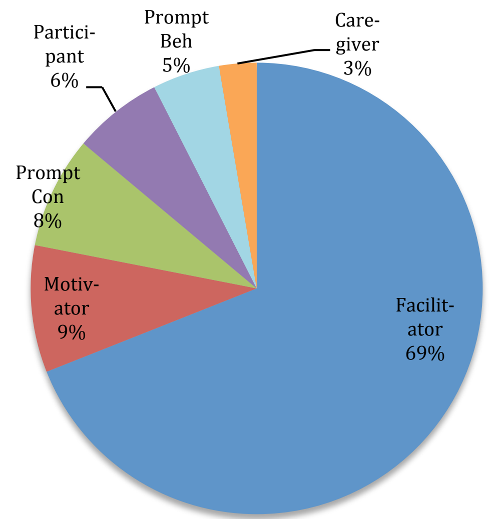
The pie charts (Graphs 7.1 and 7.2) below provide a breakdown of the active intervention from the adults within each of the design teams for each session. The pie charts indicate the percentage of the active interventions that related to each of the different roles collectively undertaken by the adults during sessions three, four and five.

7.2.1.1 ASD Teams

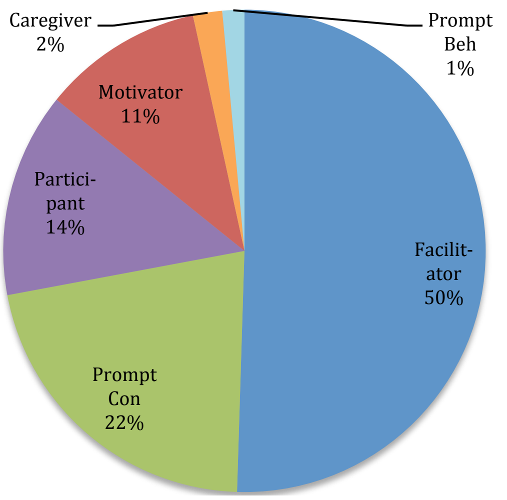
ASD Team 1	ASD Team 2

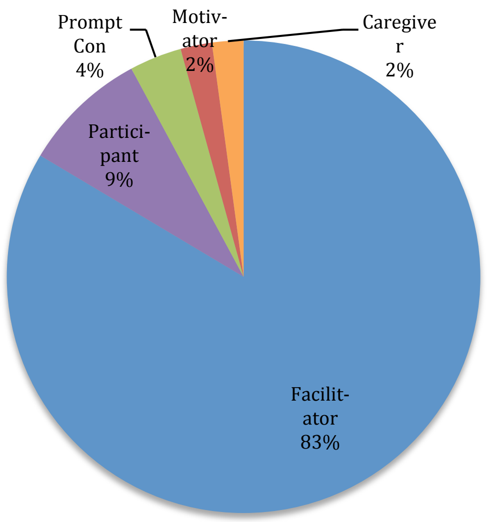
Session 3

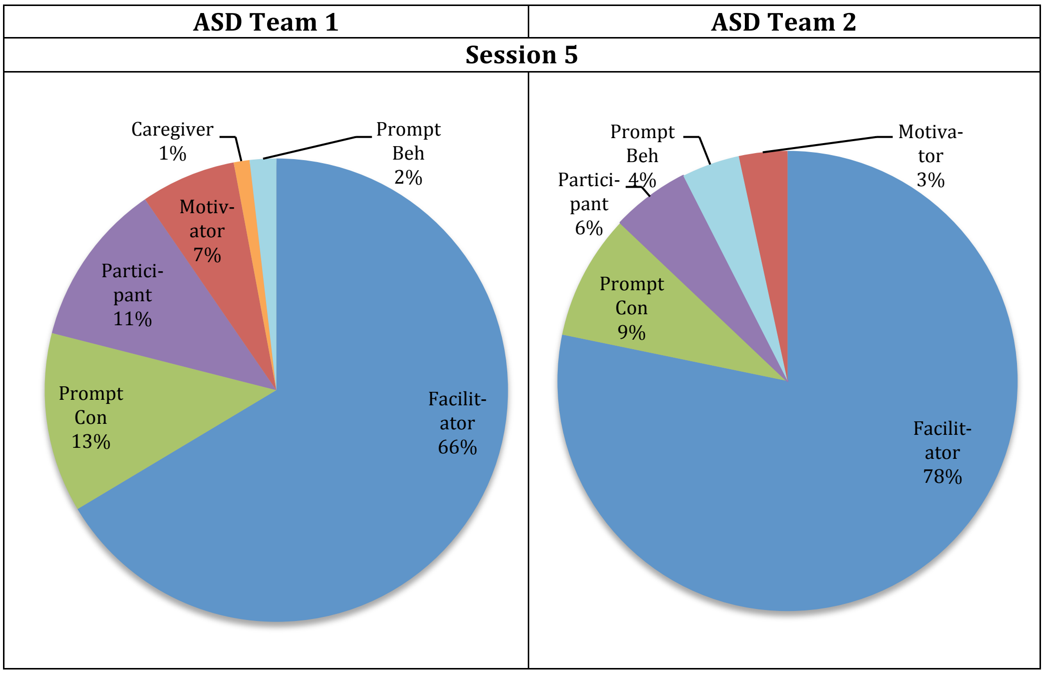




Session 4







Graph 7.1 - Breakdown of adults' roles within the ASD design teams during Study Two: sessions three - five

ASD Team 1

The above pie charts indicate a clear difference between the two ASD teams. ASD team 1 initially required more direct prompts in terms of the active intervention from the adults to enable them to make a contribution. The adults prompted the children to focus on contributing an idea for one specific element and after being prompted about specific elements several times the children were later able to generate their own ideas without such specific prompting. This initial difficulty may have been due to the sheer number of options for ideas and the problems children with ASD can experience when dealing with a more unstructured environment with many choices. Therefore even though the design space had been constrained to specific features within the game i.e. feedback or reward scheme, this may have still been too general. Providing even more constraints during the first idea generation session may help children to build up confidence in the task before widening the design space in later sessions. Additionally the need for prompts was linked with the adults providing lots of praise and encouragement, to ensure the children became confident in generating ideas and were not worried about saying the "wrong thing".

The adults also initially contributed many of their own ideas and built on the children's ideas to help provide a model for the children to follow and also provide some initial ideas for the children to then build on if they could not think of their own ideas. The pie charts show that the proportion of the active adult intervention that consisted of direct prompting within ASD team 1 was reduced over the sessions, as was the motivational support, as the children became more confident and proficient in generating and sharing their own ideas. Within ASD team 1 there were only a minor number of prompts for inappropriate behaviour and to provide additional care to ensure the children's wellbeing.

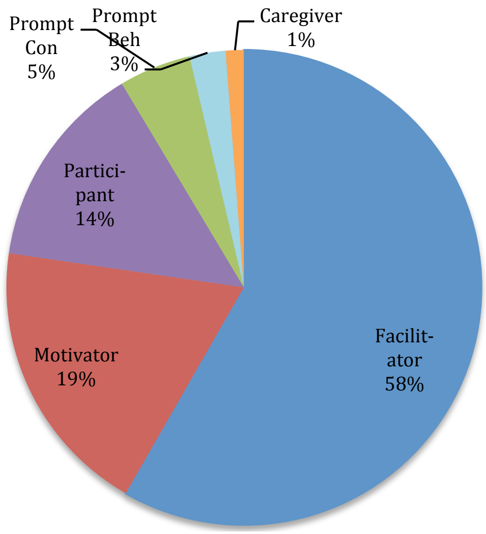
ASD Team 2

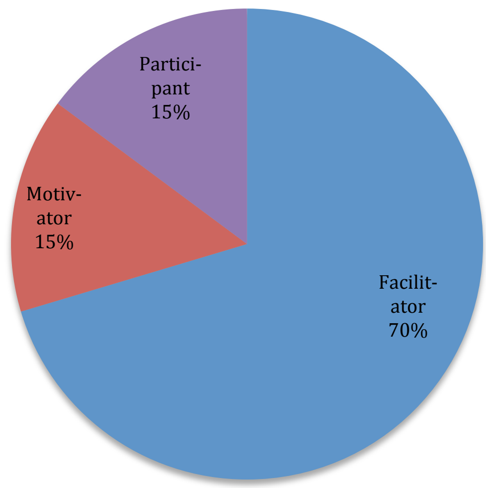
The children within ASD team 2 were much more forthcoming with ideas and began generating their own ideas from the very start of session three without any direct prompting. As they had many of their own ideas this required a greater level of adult facilitation to ensure the children expressed their ideas at the appropriate time and that it was clear exactly what the idea was the children were trying to express. The children did not require much motivational support particularly in later sessions as they were very motivated by the task and were quite confident in their knowledge and ideas about games.

The pie charts indicate that the proportion of prompting-based active intervention for specific children to contribute dropped during session four and rose again during session five. The reason for this was because one boy who often struggled to get his ideas heard was away during session four and therefore the adults had to prompt him directly during the next session to ensure he had an opportunity to contribute his ideas. A low proportion of prompts were also required for behaviour during session three and five to ensure the children took appropriate turns to speak and also that they did not go off track for too long talking about gaming in general or other topics unrelated to the actual task.

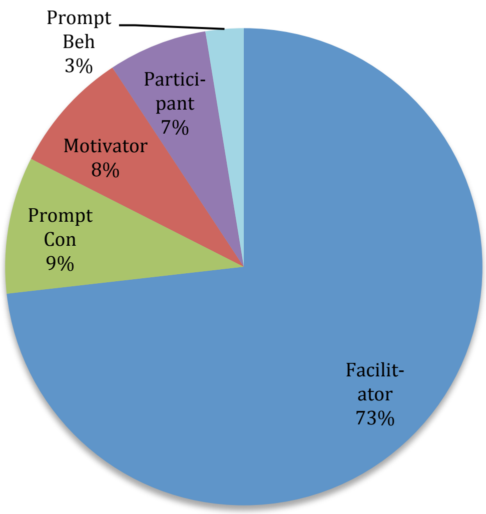
7.2.1.2 TD Teams

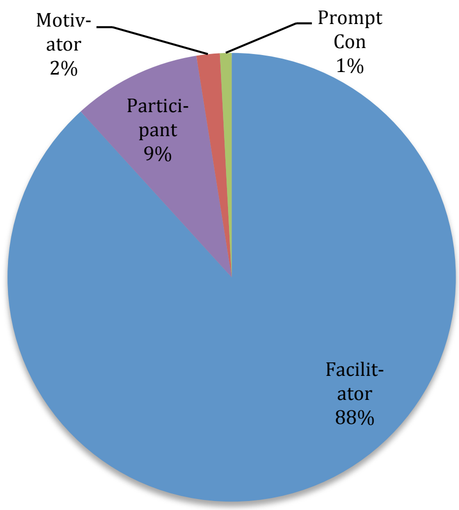
TD Team 1	**TD Team 2**
Session 3	



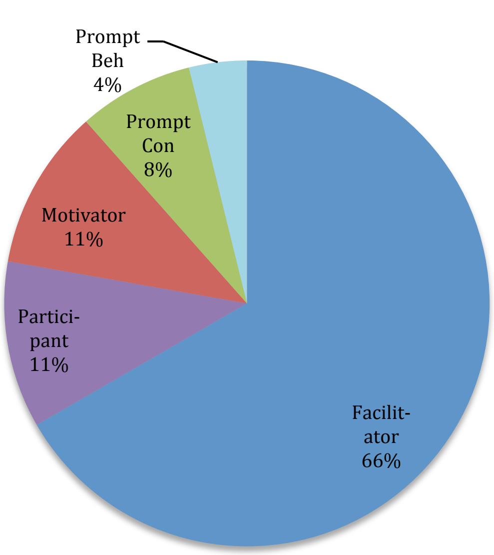


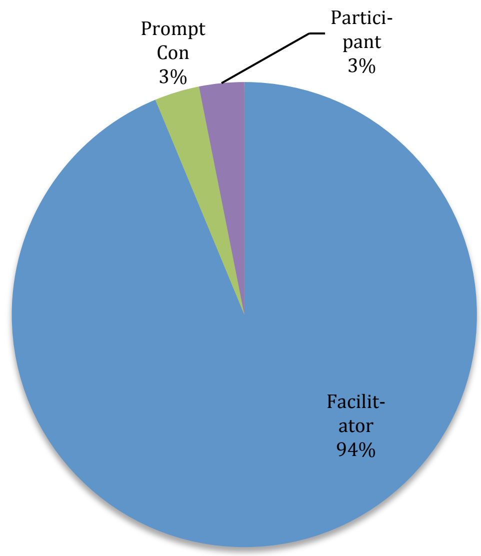
Session 4	





TD Team 1	TD Team 2
Session 5	





Graph 7.2 - Breakdown of adults' roles within the TD design teams during Study Two: sessions three - five

TD Team 1

There were also differences between the two TD teams. Initially some of the children in TD team 1 required a higher proportion of active adult intervention to provide motivational support, as there was some concern about their ability to generate good ideas. This became less of an issue during the later sessions as the children's confidence increased and this support was required to a more minor extent. The proportion of direct prompts to contribute ideas rose during the two later sessions as the children attempted to rush through the activities in order to gain more reward time on the iPad. However, they were prompted to maintain good behaviour by explaining that they were being rewarded for their contributions to the sessions and if they did not contribute anything then they would simply return to class. There were also some other minor behavioural issues, which required adult intervention to ensure the children were fully engaged in the task and not distracted by other things such as their mobile phone or other children outside the classroom.

TD Team 2

TD team 2 in contrast appeared to generate ideas without any apparent problems, with the adults simply providing motivational support to ensure they knew they were doing the right thing and generating appropriate ideas. There were no behavioural problems at all and the boys all made appropriate contributions during every session. However, the facilitation role was important to ensure the children considered all of the different aspects of the design as otherwise the boys tended to be content with what they already had and were very impressed with whatever the researchers produced in between sessions. This had an effect on the number of ideas the adults themselves generated, as the boys tended to agree with what the adults suggested and there was concern about influencing the boys' own ideas too much. There was little direct prompting of the children as the boys generally verbally contributed to each aspect of the design raised by the adult without the adult having to direct the question to individual children.

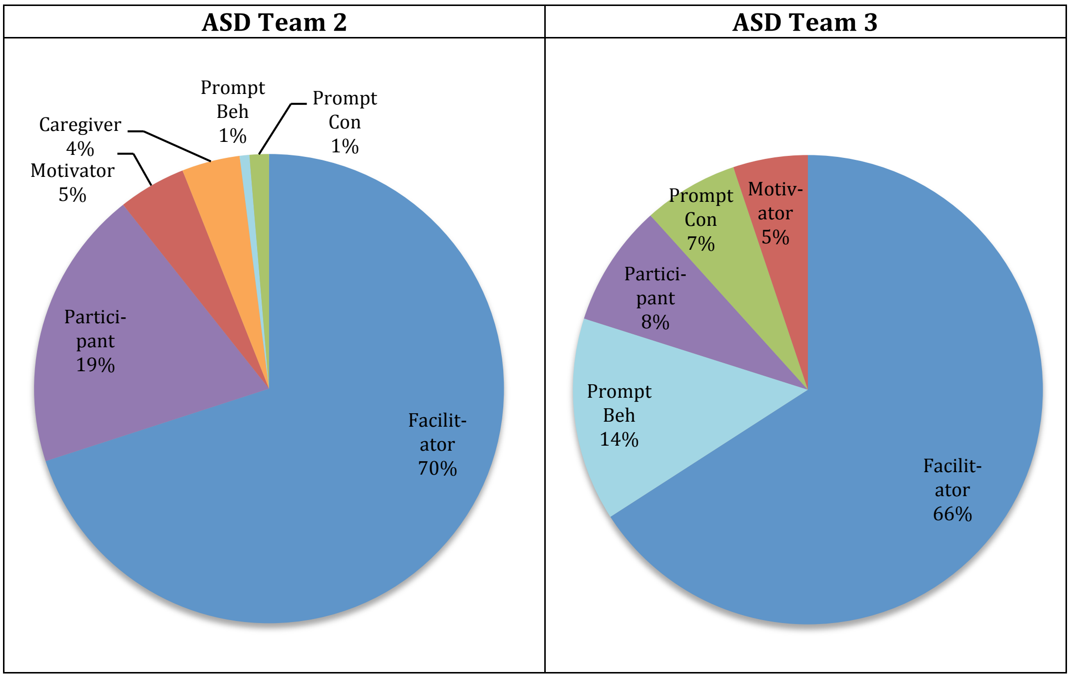
7.2.2 Study Three Adult Role Findings

The adult roles defined during the analysis of the design sessions within Study Two were then applied to the corresponding sessions within Study Three, by coding each of the utterances made by the adult researchers and teaching staff member where they actively intervened in the session in some way. Again non-task related utterances and passive intervention such as nodding and smiling were considered outside the scope of the analysis. Within Study Three there was a clear difference in the type of activities undertaken during session three (when the maths game was designed) and sessions four/five (when the maths game was built). Therefore these sessions will be discussed separately.

7.2.2.1 Session Three – Designing the Game

Firstly the roles undertaken during session three, where the initial design ideas were generated and agreed upon were explored. The pie charts (Graph 7.3) below provide a breakdown of the active intervention from the adults within each of the design teams for session three. The pie charts indicate the percentage of the active interventions that related to each of the different roles collectively undertaken by the adults during this session.

ASD Teams

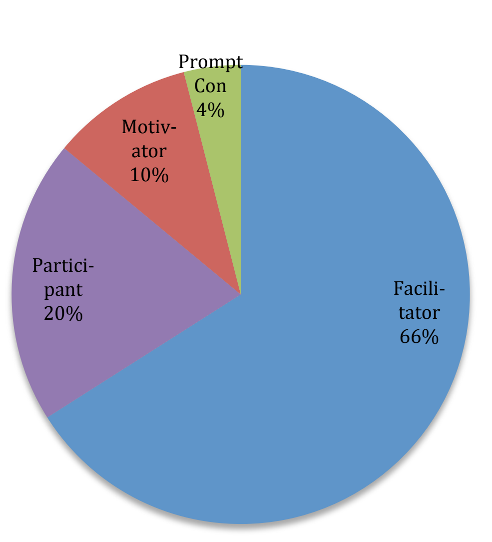
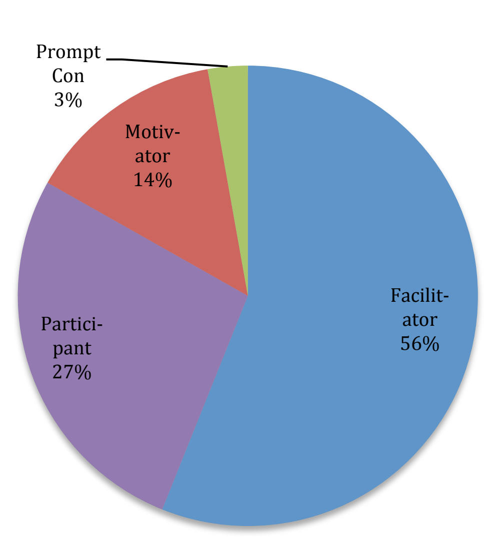


Graph 7.3 - Breakdown of adults' roles within the ASD design teams during Study Three: session three

The above pie charts demonstrate similarities with the proportion of the roles undertaken within the active adult intervention in ASD team 2 during session three in Study Two. However, the adults spent a higher proportion of this active intervention undertaking a participant role, as they were required to generate and share ideas for more game elements than within Study Two. The proportion of prompting-based intervention directed at individual children to help them to contribute ideas was very low within ASD team 2. It was also a relatively low proportion within ASD team 3, particularly in comparison to the proportion of direct prompting required within ASD team 1 during Study Two. This was also true of the proportion of motivational support required in terms of providing praise and encouragement to ensure continued engagement in the activities.

There was a clear difference in the prompting for behaviour role between the ASD teams, which was a much higher proportion of the active adult intervention within ASD team 3. The adults were required to more frequently prompt the children to maintain good behaviour to prevent them talking over other team members and digressing too much from the task. This increased behaviour management role meant that the adults were required to monitor behaviour more, meaning they were less able to participate as equal participants by sharing and discussing ideas. Later within the session the teaching staff member developed a strategy to increase the focus of the children by providing more structure to the discussion through explicitly requiring the children to turn-take, sharing all of their ideas one at a time. This highlights the difficulties some children with ASD can experience within a semi-structured discussion and the need to revert to a more highly structured discussion if the children are struggling to focus.

TD Teams

TD Team 2	TD Team 3
	

Graph 7.4 - Breakdown of adults' roles within the TD design teams during Study Three: session three

The above pie charts show there were a similar proportion of facilitation-based interventions to the ASD teams within TD team 2, but a slightly lower proportion within TD team 3. This was due to the adults undertaking a greater participant role, which could be at least partly explained by the difficulty that the children within TD team 3 had with generating appropriate ideas for the maths topic game element (discussed within the previous chapter). This resulted in the adults suggesting more ideas for this game element to help the children understand the type of ideas that were being asked for. Both pie charts also highlight an increased proportion of motivational statements used by the adults within both teams. As there were no behavioural issues during this session the adults did not need to worry about managing behaviour and were able to instead focus on praising the children's ideas to help build confidence.

7.2.2.2 Sessions Four and Five – Building the Game

During sessions four and five the proportion of the adults' role as a participant decreased substantially to >=3% within the ASD teams and >=4% within the TD teams. This highlights the fact that the children were able to take the lead in progressing the team ideas using Scratch and increasing their level of participation within the process. As a result of this the proportion of the facilitation-based role undertaken by the adults within all of the teams increased significantly during sessions four and five.

Within the TD teams facilitation accounted for 89-98% of the adult's total active intervention during sessions four and five. It was also very high within ASD team 2, accounting for 89-91% of the adults' active intervention across both sessions. However, it was slightly lower within **ASD team 3** at 88% during session four and 77% during session five. This difference was again due to the behavioural issues, with the adults having to spend between 7% and 14% of their active intervention managing behaviour across the two sessions, which was mainly due the children's difficulty working as a team. This finding is not surprising considering the social and communication issues typically experienced by individuals with ASD. However, the adults within ASD team 2 were only required to spend 4% of their active intervention managing behaviour, and there are two potential factors that affected the more appropriate behaviour within this team. Firstly the children in this team had participated within the previous study and therefore had prior experience working together. Additionally due to one boy leaving the school, this team only had two child members during session four and five, and having one less team member than ASD team 3 would have made it easier to turn take and share resources.

The facilitation role undertaken by the adults during sessions four and five within Study Three incorporated a number of aspects due to the differing nature of the build activities compared to Study Two, which solely involved design activities. This means that the definition of the facilitation role within this context needs to be expanded to incorporate the coordination of access to resources and also to provide appropriate technical support to enable the children to achieve their initial design goals.

7.2.3 Summary of Adult Role Findings

The findings in terms of the adults' role within each design team show that the adults were required to take on different roles throughout the sessions, transitioning between roles depending on the current needs of the children. The roles of the adults were also dependent on the activity focus, whether it be designing or building the technology, and the level of the child's participation within each activity.

The proportion of time spent undertaking each role differed across sessions and also between the teams. Each team had their own personal needs and this was true whether the children were diagnosed with ASD or not. This reflects the findings of Read et al. (2002) who found the type of role undertaken by the adult within their design teams was determined by the children's contributions to the design. They also found clear differences between the different design teams, each starting at a different position on their continuum of participation model and transitioning between different modes throughout the design session. Read et al. (2002) have proposed four variables which have the potential to impact the balance of participation within the group, including:

- *Environment* – the physical and cultural setting in which the design sessions are undertaken
- *Skills* – the cognitive, motor and articulatory skills of each participant
- *Security* –comfort factors, emotional stability and levels of stress
- *Knowledge* – the general, subject and technical knowledge of each participant

7.2.3.1 Environment

The *environment* was generally quite a consistent variable across all of the groups, as all of the sessions took place in a separate classroom at the children's schools and therefore should have had a similar impact across all of the groups. Also the children were all from urban non-faith state schools and therefore came from relatively similar backgrounds. However, one potential influence on TD team 2 and TD team 3 was the fact that the teaching staff member involved in those teams was the only maths teacher who took part in the study (the others included a teacher responsible for pastoral care, and two teaching assistants) and therefore it may have been slightly more intimidating for these children, resulting in them being less likely to question what the adults said.

7.2.3.2 Skills

There are many *skills* required to be a successful design team member and the variation in skills between the teams and the children and adults within the teams did have an impact on the sessions. The difficulty the children in ASD team 1 experienced in initially generating and/or sharing their ideas resulted in the adults both prompting for specific contributions and suggesting ideas to provide a model to support the children develop their skills in this area. The adults within ASD team 2 and ASD team 3 also had to support the difficulty the children sometimes had with teamwork skills such as turn taking and listening to others. Furthermore, the children in TD team 1 exhibited difficulties with maintaining concentration and again this was something that required the adult to intervene with behavioural prompts and additional facilitation.

7.2.3.3 Security

There were indications that feelings of *security* varied across the teams and also across the different sessions within the same team. The high level of knowledge of computer games within ASD team 2 and ASD team 3 (excluding M16) seemed to give them confidence in expressing their ideas and disagreeing with any suggestions from the adults which they did not like or agree with. The children in ASD team 1 seemed initially concerned about participating within an activity that they were unsure about and therefore the adult support and encouragement was essential to increase their comfort in participating in this activity. There were also evident insecurities within TD team 1, with some children lacking in confidence in their ideas and in sharing them with the rest of the team. Again adult motivational support through praise and encouragement was essential to build up this confidence.

7.2.3.4 Knowledge

The children in all teams were very familiar with computers and all enjoyed playing games in their spare time (except for M16 within ASD team 3). Therefore the majority of the children had similar level of *knowledge* about the computer game aspect of the design task. Within ASD team 3 the other children were aware that M16 did not play many computer games and would explain any technical game-related concepts to him. Also as the generation of game ideas was divided into basic elements and each element explained before idea generation began, having a high level of computer game knowledge was not essential to participate within the sessions.

The children had different levels of maths ability. However, within Study Two the maths was kept extremely basic (i.e. simple addition and subtraction) and therefore this did not hinder the children in any way. Within Study Three the children were given the opportunity to choose the topic and level of maths incorporated within their game. There was less variation in the ability of the TD children and therefore it was reasonably straightforward for them to pick a maths topic and level that was understood by all. However, the maths ability varied more within the ASD teams, with the higher ability children within both teams picking topics that other children struggled to understand. This resulted in these children being unable to contribute to the aspects of the sessions focused on the maths content, and in some cases becoming disengaged from the activity. This required an adult to maintain awareness of this and find ways for the child to still make a contribution to the activity. This highlights the importance of ensuring a closer match in the ability levels of the children within the design team when designing educational technology with more complex content.

The children in ASD team 2 appeared to spend a large amount of their spare time playing computer games. This resulted in a large number of unprompted ideas based on their experiences of playing various games and was something they were very keen to share due to the link between the design topic and their special interests. This detailed knowledge therefore had a positive impact on the performance of this team. The influence of high levels of knowledge gained due to the special interests of the children with ASD was also evident within ASD team 3, where M16 who had less knowledge of computer games but had a special interest in music was able to make a significant contribution to which sounds were included within their game. This helped to engage him within an activity he did not initially have a natural interest in.

Finally within Study Three the children were required to develop the technical knowledge to build their games within Scratch. Some of the TD children within both teams had previously used Scratch at school. However, this did not negatively impact the children who had not used Scratch before as the tutorial helped to provide the appropriate knowledge for the later build sessions and the adult researchers were able to provide additional support during the build sessions if a child became stuck. The children with the prior knowledge were also encouraged to help their less experienced team members and they were observed doing so on several occasions.

None of the children with ASD had used Scratch before and therefore they all came into the sessions with the same level of knowledge. However, some of the children learned Scratch at a much faster pace than others within the team. This had an impact on the later sessions, as they were able to dominate the building of the game because they had a greater understanding of how to implement the design ideas, excluding the other children from participating in certain aspects of the sessions. This again highlights the need to establish the ability levels of the children with ASD prior to forming the design teams, to ensure the children have similar levels of technical ability.

Implicit Knowledge

During the analysis of the adults' various roles it became clear that the teaching staff members within the ASD teams were able to contribute something more to the sessions than the researchers were able to, which was specific knowledge about the school and the children. The teachers within the TD teams did not have the same level of familiarity with the children simply due to the mainstream secondary school environment whereby teachers teach many different children and the disparity in numbers of pupils that attend the different schools. However, this implicit knowledge the teaching staff members at the ASD schools had appeared to be important for supporting the participation of the children with ASD and included having knowledge about the following:

- How to phrase questions so the children will answer them appropriately due to their literal interpretation of language. For example knowing the difference between *"would you like to share your idea?"* and *"will you share your idea?"*.
- The specific interests of the children and being able to incorporate them into the activities to help the children understand what they are being asked to do. For example for a child that liked The Simpsons when asked to provide ideas for feedback on incorrect answers phrasing it as *"What would Homer say when there's something wrong?"*.
- Providing additional appropriate structure when the children are experiencing difficulty with an activity. For example focusing the children on a specific element of the activity when they are unsure where to begin and structuring the turn taking within a discussion activity.

- The specific sensitivities of the children and how much they are able to deal with. For example in terms of certain sounds like high-pitched sound effects or tactile sensitivities such as touching paper.
- Interpreting exactly why a child does not like something even if they are unable to express the reasons themselves.
- How to increase the child's motivation/engagement within the session. For example by pointing out the activity they would instead be doing in class.
- When the child should be praised, as children with ASD can struggle with a wide range of different things and a small change in behaviour can be a big achievement for certain children, which the researchers would not necessarily have recognised.
- Providing additional explanation of an activity by relating it to a previous experience the children have had.
- Recognising when a child really has a problem or if they are simply attention seeking.
- Setting up the environment to best support the children's participation by making it as comfortable as possible. For example adjusting the room temperature or providing drinks of water.
- Ensuring the appropriate school rules are enforced throughout the session as they would be in class to provide consistency for the children and reduce any confusion in terms of different expectations during the design sessions and during their other lessons.

This knowledge helped to ensure the success of the sessions, but is something that is built up over a significant period of time (up to years) spent working with the specific children as well as children with ASD in general. Therefore it would be very difficult for a researcher to build up the same level of knowledge prior to conducting the sessions, highlighting the importance of the teaching staff member's role within the team.

The teachers within the TD teams had the school knowledge, but did not have knowledge about the specific children. It is difficult to establish if this had a detrimental effect on the sessions or not, as the TD children were better able to verbally express their preferences and difficulties without additional support from the adults. However, the importance of this implicit knowledge within the ASD teams has implications for PD in terms of team constitution. It also highlights the need to incorporate this variable within the knowledge class, as defined by Read et al. (2002), when involving children with particular special needs within the technology design process.

7.3 Engagement Techniques

This section addresses the sub-research question **RQ2b) What are the most effective techniques for engaging children with ASD as active participants within the technology design process?** One of the key aims of this thesis is to explore how children with ASD can undertake a more involved role within the PD process and therefore it is important to identify which specific technique(s) are successful in enabling this. In order to determine how to effectively engage children within the design process, the child participants within both studies were asked to complete two surveys at the end of the process. One survey asked about i) their opinion of their experience of taking part in the sessions and the other survey asked about ii) their opinion of their final prototype maths game. During the final session the children were also asked to produce a display of work detailing the activities they had undertaken across the previous five sessions and what they liked/disliked about these activities. The results from these surveys and the final display of work have been analysed and the findings discussed below in terms of the implications for the children's engagement within the sessions.

7.3.1 Establishing Effective Techniques for Engagement

During the final session in both studies the design teams participated in an activity to create a display of work representing what they had achieved over the previous five sessions (see Fig. 7.1). As part of this activity they were asked to complete a paper template for each session that included reflecting on what they had done during the sessions and answering questions about their likes and dislikes to determine the specific activities that were successful at engaging the children. However, the templates the children were provided with differed slightly between Study Two and Study Three. Within Study Two the children were provided with a separate template for each session, with questions asking what they did, what they liked and what they did not like. This was combined into a single template within Study Three, with the activities solely being represented by the images on the template and the questions including what activities were most enjoyed and why, what activities were least enjoyed and why, and what was learnt. This helped to make the task more succinct and allow time for other evaluation information to be gathered including their collective opinions relating to the teamwork, ideas generated and final game.

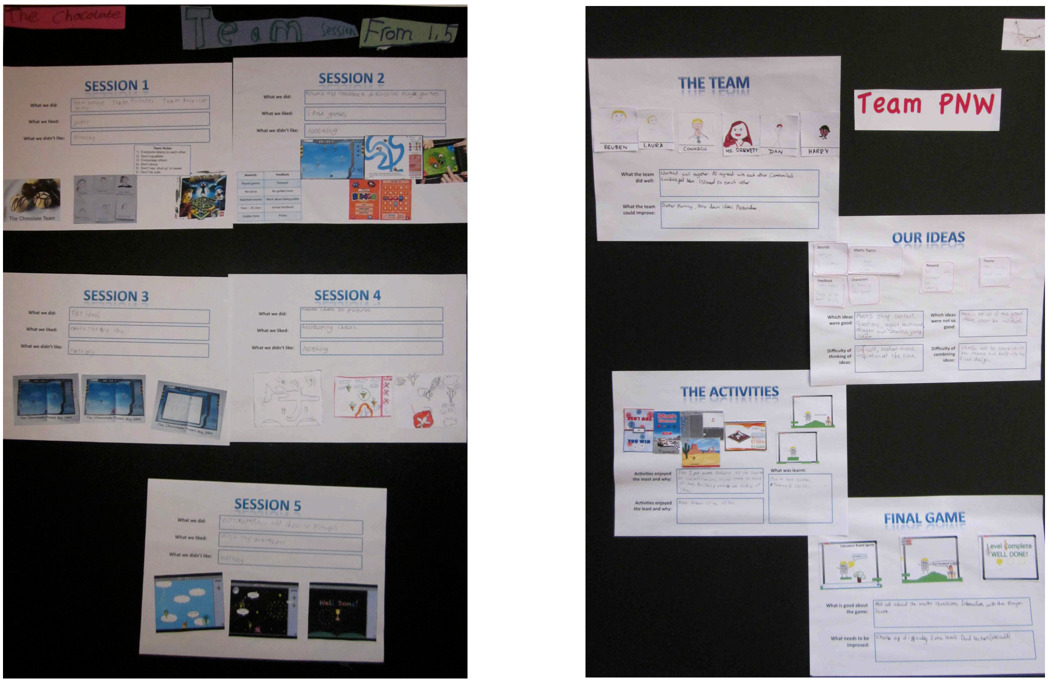


Figure 7.1 – Display of work produced in session six during Study Two (left) and Study Three (right)

In addition to this after the final session the child participants completed a survey (with the help of the teaching staff member) to establish their overall opinion of participating in the design process. This survey incorporated a Smileyometer Likert (Read and MacFarlane, 2006). The Smileyometer was used to determine the children's opinions of participating in the different activities involved in the sessions. There were also a number of multiple-choice questions, with a limited number of simple options, to ensure that the survey was as straightforward as possible for the child to understand and to minimise the amount of writing they had to do. The full survey for both studies can be found in Appendix C. The questions asked differed between Study Two and Three to reflect the nature of the activities incorporated within the study. The Study Two survey focused on the experience of designing a game and the Study Three survey focused more on the experience of building the game. The results of both the display of work activity and the Participation Experience surveys have been analysed to establish the extent of the children's engagement within the sessions and which activities have been most effective in this engagement.

7.3.2 Study Two and Study Three Engagement Findings

A summary of the Participation Experience survey results from Studies Two and Three can be found in Tables 7.3 and 7.4. Overall the feedback was positive for all the different aspects of the participation experience including generating, drawing and discussing ideas within Study Two and learning to use Scratch and building the game within Study Three, as well as working with the rest of the team. In Study Three the children were also asked if they had the choice whether they would prefer to just design the game or design *and build* it themselves. All of the children answered that they would prefer to design and build the game themselves except for one boy from TD team 3. The fact that all of the children that had previously taken part in the previous study where they only got to design the game preferred to also build the game highlights that increasing their level of participation within the process had a positive impact on their participation experience.

	ASD Team 1	ASD Team 2	TD Team 1	TD Team 2
Designing a maths game	Good	Really Good	Really Good	Really Good
Working with the team	Really Good	Really Good	Really Good	Really Good
Thinking of own ideas	Really Good	Really Good	Really Good	Really Good
Drawing ideas	Really Good	Good	Good	Really Good
Talking about ideas with team	Good	Really Good	Really Good	Really Good
Seeing ideas on computer	Good	Really Good	Brilliant	Brilliant
Using the iPad	Really Good	Really Good	Brilliant	Brilliant

Table 7.3 - Summary of results of Participation Experience survey from *Study Two* (shows average of ratings from each design team)

	ASD Team 2	ASD Team 3	TD Team 2	TD Team 3
Designing a maths game	Really Good	Really Good	Really Good	Brilliant
Building a maths game	Good	Really Good	Brilliant	Really Good
Working with the team	Good	Good	Brilliant	Really Good
Learning to use Scratch	Good	Really Good	Really Good	Really Good
Using the iPad	Really Good	Really Good	Brilliant	Brilliant

Table 7.4 - Summary of results of Participation Experience survey from *Study Three* (shows average of ratings from each design team)

The specific engagement findings from the display of work activity are discussed below and summarised in Table 7.5.

7.3.2.1 Specific Activities: Study Two

During the final display of work activity within Study Two all of the children highlighted the *LEGO© game activity* and playing the *iPad games* as activities that they particularly liked. Both ASD teams and TD team 2 liked *watching the demo videos* of their games. ASD team 1 said they liked *creating the "big idea"* during session 3 (combining their ideas together) and also *developing/improving upon their ideas*, as did TD team 1. ASD team 2 said they liked *"discussing the context stuff"* and getting to see the first *computer-based stills* of the game because it had been improved dramatically. They said they liked *coming up with their own ideas*, as did both the TD teams. Both the TD teams also mentioned they *liked the drawing parts* of the sessions.

In contrast to the TD teams neither ASD team mentioned drawing as something they liked and ASD team 1 explicitly said that they did not like drawing the team portraits during the first session. Drawing ability was highlighted as a concern during Study One and this reinforces the fact that design activities should include alternatives to drawing. Particularly as in this case the children with ASD generally appeared happier to explain their ideas verbally with an adult documenting the ideas on the paper template. ASD team 2 felt frustrated during the first two sessions, as they wanted to get on with the task of making the game. Neither TD team specified anything that they particularly disliked about any of the sessions. However, it is not known if this is because they enjoyed everything or they were concerned about pleasing the researchers, whereas the ASD teams may have been happier to say when they did not like something.

7.3.2.2 Specific Activities: Study Three

During the display making activity within Study Three all of the children highlighted that their most enjoyed activities involved using the *iPad*. The children within ASD team 3 said they were *"fun, educational and interesting"* and the children within TD team saying they liked using them to think of ideas. The children in ASD team 2 and the TD teams also said they liked *designing their games*, and TD team 2 particularly enjoyed *thinking of ideas* for the game. The children were generally quite positive about using Scratch with TD team 2 enjoying *building their game* and TD team 3 highlighting the game they built during the Scratch tutorial session as being good. The children in ASD team 1 stated they enjoyed *creating their sprites* (game characters) within Scratch, but M4 would have preferred to design the game in Scratch straight away rather than using the paper templates.

However, the feedback relating to Scratch was not universally positive and some of the children with ASD mentioned Scratch when asked about their least liked activities. The children in ASD team 3 felt that *"Scratch had a rough start but it got better in the end"* and M3 within ASD team 2 also said he did not enjoy using Scratch and preferred using other game development tools. M3 had very high expectations of what their game should look like and was unable to create a game that looked as polished as the computer games he typically played outside of the sessions, saying he preferred the game they created during Study Two (which had more of a polished look). He also stated that something he disliked at the sessions was "*not having enough time"* and this was also a limiting factor in which of their game ideas (of which there were many) they were able to implement. Finally the children in TD team 1 said there was nothing they disliked about the activities they participated in and one boy in TD team 2 stated he only disliked playing some of the harder iPad games. The other members of TD team 2 did not express any other dislikes.

7.3.2.3 Working in a Team: Study Two

Interestingly both ASD teams rated working with the team on average as 'Really Good' and all children said they would rather design the game with the team than on their own (as would the TD children). It is surprising that all of the children felt this as children with ASD can typically struggle and become frustrated within situations that require social and communication skills such as working within a design team. This positive feedback could potentially relate to one of many factors such as the structure and support provided to enable them to participate successfully, resulting in a more positive experience of this type of environment.

7.3.2.4 Working in a Team: Study Three

Within the Participation Experience survey in Study Three all of the TD children were very positive about working in a team as they stated that working in a team was 'Really Good' or 'Brilliant'. They also all said that they would rather design and build the game with the team than on their own. However, the children with ASD were less positive about working in a team in this study. M3 from ASD team 2 and M11 from ASD team 3 both thought that working with others did not improve their final game and they both would rather design and build the game on their own, as would M16. For M3 this was a change from his opinions during Study Two where he said he preferred working with the team, but the fact he was not as happy with the game they produced may have impacted his overall opinion of working with the team in this study.
The display of work activity within Study Three also incorporated a template to stimulate discussions around teamwork asking the questions "What did the team do well?" and "What could the team improve?". Although the children with ASD were generally less positive about working in a team they were able to highlight some things they did well as a team. For ASD team 2 this included designing and communicating as well as getting to know each other. M3 who had originally stated within his survey that the team were 'Not Very Good', later conceded during the discussion they were actually pretty good. The reason for this difference of opinions between the two boys was that M3 had higher expectations of the game and thought they could have done a better job, with the main issue being they did not have a very good work ethic. M3 said he thought the team *"had too much fun"*, whereas M4 seemed to particularly enjoy the teamwork and said one of the most positive aspects was that he had made "*a closer friend*" in M3.

The children in ASD team 3 highlighted picking the sounds and objects within the game as well as playing the iPad games together as something they did well as a team. However, M12 and M13 felt that M11 did not listen to their ideas, which made it difficult to combine ideas together. Although he did not participate in the display of work activity M11's negative view of the team expressed within the survey is reflective of his attitude during the sessions where it seemed like he viewed the others as more of a barrier than an aid to completing the game. He already had a clear idea of the game in his head and negotiating ideas and control with them wasted time. He also had high standards of what he wanted to achieve during the sessions and it appeared the team did not manage to meet these, which frustrated him.

The build activities within Study Three required the children to use teamwork skills more frequently than in the previous study, as they needed to cooperate with each other to share resources as well as listen to each other's ideas and make compromises when deciding which ideas to implement within their game. This was something moderated more by the adults during Study Two. Therefore due to the social and communication problems experienced by children with ASD this task would have been much more difficult for the ASD teams, potentially resulting in the view that it would be easier to do it on their own. However, the fact that they could accept that working together was part of the design task and were still able to highlight some positives related to the experience indicates that working within a design team did not become a complete barrier to their participation. This also raises the issue of what it is best to support the children to collaborate on, the potential of the children undertaking individual activities that could contribute towards a common goal and the implications of the choice of resources within an activity, which will be discussed in more detail in the following chapter.

Successful techniques for engagement in PD	Study Two		Study Three	
	ASD Teams	TD Teams	ASD Teams	TD Teams
Demonstration and playing of existing games	✓	✓	✓	✓
Generating and developing design ideas	✓	✓	✓	✓
Drawing-based activities		✓		
Demonstration of game prototype	✓	✓		
Building game				✓
Working in a team	✓	✓	✓ (some children)	✓

Table 7.5 – Successful techniques for engaging children within the technology design process

7.3.2.5 Overall Experience: Study Two

In the Study Two survey all of the children from both ASD and TD teams also said they would take part again if they could, except for one boy from ASD Team 1 who said he maybe would. Children with ASD can be brutally honest and would express their dislike if they did not enjoy participating in the sessions therefore these positive responses are a strong indication that the design sessions did provide an enjoyable experience for the children. The children were also asked if they thought that adults should always ask children for their input when designing computer games or programs for them. This question received a mixed response from all teams; with several children saying yes and others saying that adults should sometimes ask.

7.3.2.6 Overall Experience: Study Three

In the Study Three survey the majority of the children said they would take part again with the exception of M13 from ASD team 3 and M14 from TD team 2 who said they ‘Maybe’ would and M11 from ASD team 3 who said he would not take part again. M11’s response may have been due to his difficulties working with the rest of the team to complete the task and his frustration at being unable to produce a final game that met his high standards. The children were also again asked if they thought that adults should always ask children for their input when designing computer games or programs for them. Again there was a mixed response to this question with the children saying yes or sometimes.

The findings discussed above have generally indicated high levels of engagement within the activities in both studies. However, an increased demand on having a high level of teamwork skills within Study Three negatively impacted the participation of some children with ASD, who struggled to work with others on some of the activities and felt that this decreased the overall quality of their final game.

7.4 Benefits of Children’s Participation

This section focuses on the sub-research question **RQ2c) Does participating in the technology design process benefit children with ASD in any way?** Hussain (2010) highlights the importance of developing confidence in sharing ideas and opinions within the team as well as the development of new skills, in empowering the participation of children within the technology design process. Therefore it is important to examine the benefits of engaging the children within the technology design process. In order to establish if participating in the sessions during both Study Two and Study Three benefited the children, the teaching staff members from the children’s school who had participated in the sessions were asked to complete a survey. The survey asked about their opinions on the children's engagement within the sessions and if they thought the children benefited in any way.

Each teacher or teaching assistant (TA) completed a survey after the final session in both studies, which asked them about whether the children were happy to take part, whether the children benefited from their participation, what the most positive aspects of the sessions were and what could be improved (the full survey and results can be found in Appendix C). The results from these surveys have also been analysed to establish the children's enjoyment of the sessions and if their participation in this process had any positive (or negative) impact upon them.

7.4.1 Study Two Participation Benefits

The teaching staff members from all of the teams (both ASD and TD) in Study Two said that they thought the children were happy to participate. The TA from ASD team 1 said that she knew this because the children continued to ask if they would be doing any more sessions after the last session was completed and that they would have shown her their displeasure if they were not happy. The TA from ASD team 2 said she thought they were happy because they all joined in with the sessions. Children with ASD can be very uncooperative if they do not want to do something (Attwood, 1998) and therefore if they did not like participating in the sessions then they most likely would not have joined in.

7.4.1.1 Specific Benefits

Table 7.6 provides an overview of the specific benefits stated by the teaching staff members. All of the teaching staff members thought that the children benefited from participating in the sessions with the TA from ASD team 1 saying that it taught each of the children a new skill including turn-taking, compromising, building relationships with the adults and gaining confidence to voice opinions. The TA from ASD team 2 thought the children learned better teamwork, which was also true of the teachers in both TD teams. They also thought the TD children learnt to engage with different students, listen and respect each others' ideas as well as come up with their own ideas. Both the TAs from the ASD teams considered it beneficial that the children were part of a process that was fun and allowed them to see their ideas develop, with the TA from ASD team 1 saying it gave all of the children "a big confidence boost".

7.4.1.2 Most Positive Aspects

In terms of the most positive aspect of the sessions the TA from ASD team 1 highlighted several aspects including the relationship between the children and adults, which developed as the children saw their ideas come to life through the adults listening and taking on board what they had to say. She also commented *"the way the sessions were structured, visual and recapped was brilliant – visual examples helped them get ideas but not copy, making them use their imagination"*. The TA from ASD team 2 thought the fun aspect of the sessions was very positive as it meant the children did work without realising it and she also thought it broke up their working week with something *creative*. Both TAs mentioned the fact the sessions provided an opportunity for the children to use their imagination or be creative, highlighting the potential involvement in the technology design process can offer children with ASD in terms of developing/practicing their creativity skills.

The teachers from the TD teams highlighted the positive aspects of being involved in i) designing something for someone else to use, ii) feeling part of a team and iii) providing the children an opportunity for adults to listen to their ideas. The teacher from TD team 1 also felt that the boundaries and rules made it easy for the children to follow and being given the responsibility for checking off the tasks gave the children a sense of ownership over the sessions.

7.4.2 Study Three Participation Benefits

The teaching staff members from all of the teams (both ASD and TD) in Study Three said that they thought the children were happy to participate. The TA who worked with the ASD team said she knew this because computer games were a big part of the children's lives and they enjoyed learning how to design and build a game themselves and also because they interacted well. The teacher who worked with the TD teams said they were happy to participate because they enjoyed building the game.

7.4.2.1 Specific Benefits

Table 7.6 provides an overview of the specific benefits stated by the teaching staff members involved in Study Three. All of the teaching staff members thought that the children benefited from participating in the sessions. The TA involved in both the ASD teams stated that this was because it was something new, fun and exciting; there was good interaction between the children and that they also benefited because of the team building. She said that it taught the children computer skills, about programming in Scratch, teamwork/social skills and how to share. During the display of work activity the children from the ASD teams also highlighted that they learned about using Scratch, with the children from ASD team 2 also saying they learned about games development and *"the value of friendship"*.

The teacher who worked with both TD teams said it benefited the children because it was different to normal lessons and was an opportunity to work as part of a small group. She said that it taught them programming skills and how to work as a team that included pupils from different years and adults other than their usual teachers. However, she did also highlight the issue of the children having to miss their normal lessons as a potential downside. During the display of work activity the children from the TD teams stated similar skills saying they learned how to use Scratch and teamwork skills.

Benefit	**Study Two**		**Study Three**	
	ASD Teams	**TD Teams**	**ASD Teams**	**TD Teams**
Turn-taking skills	✓			
Compromising skills	✓			
Improved relationship with adults	✓	✓		✓
Increased Confidence	✓			✓
Teamwork/Social skills	✓	✓	✓	✓
Engage with others (of different ages)		✓		✓
Listen and respect others' ideas		✓		
Imagination/Creativity skills	✓	✓		
Thinking about others		✓		
Feeling part of a team		✓		
Sense of ownership		✓		
Technical skills			✓	✓
Enjoyment	✓	✓	✓	✓
Learning to share			✓	

Table 7.6 – Benefits for children participating in the technology design process

7.4.2.2 Most Positive Aspects

In terms of the most positive aspects of the session the TA who worked with the ASD teams thought it was being able to see the final product of their work at the end (the children were also given a CD copy of their game with a printed cover acknowledging their involvement as game developers). She said she herself had learnt *"Group/team work is possible"*. The teacher from the TD teams highlighted the most positive aspects of the sessions as having the opportunity to work as a small group, having their ideas listened to and feeling "chosen" to take part, which she felt improved their confidence.

Although it is difficult to compare the benefits across the two studies, as the benefits have been measured in a subjective way, it is clear that that one unique benefit from Study Three was the development of technical skills through learning to use a visual programming environment. Overall the findings from the surveys within both studies indicate that participation in the sessions was a beneficial experience for the children in all of the design teams, offering them opportunities to develop skills particularly in relation to teamwork, to boost their confidence and to develop a sense of ownership and empowerment over the process. This shows that it is important and valuable to consider the benefit of participation in the technology design process in addition to the outcome of the process.

7.5 Summary of Participation Findings from Studies Two and Three

This chapter has discussed the participation findings within a collaborative design environment during Studies Two and Three. Both studies involved four design teams, which included children, teaching staff members and researchers. The level of the children's participation was increased within Study Three when the children were additionally involved in building the prototype technology, rather than solely being involved in the design phase. The key findings from this chapter are summarised below, presented under each of the sub-research questions that guided the analysis.

7.5.1 Relevance to Research Questions

RQ2a) What role do adults need to play to best enable the participation of children with ASD within the technology design process?

The role of the adult was examined in detail and it was established that the nature of this role is dependant on the support the individual children require. It was also recognised that the adult can be required to transition between several different roles during the sessions as well as the nature of the role evolving over time. It was found that some children require more motivational support, explicit prompting and model ideas to start with. This was particularly helpful for children who appeared overwhelmed with the initial design task, by focusing their attention onto a more specific element of the design. This preference is predicted by the WCC theory (Happé and Frith, 2006), which highlights the tendency of children with ASD to focus on the finer details and struggling to understand the 'bigger picture'.

There is also a need to facilitate the children's own ideas to enable them to express these ideas clearly and ensure all child participants are given the opportunity to share their ideas. There was a clear difference in the roles that the adults undertook during the design phase within Study Two and the build phase within Study Three, with the children's level of participation within the activities increasing and the adults required to mainly facilitate this participation.

It was established that the knowledge, skills and feelings of security of the child participants could all potentially impact the level of the child's participation within the sessions and have implications for the resulting role of the adults within the team. Lastly, the specific role of the teaching staff member also emerged, it was evident that they had implicit knowledge that enabled them to support the participation of the children with ASD, which was knowledge the researchers did not have.

RQ2b) What are the most effective techniques for engaging children with ASD as active participants within the technology design process?

There appeared to be high levels of engagement in the sessions, with predominantly positive responses to the different design and build activities that the children participated in. Within Study Two the children in the ASD teams particularly liked playing both board and computer games as well as watching the demo videos of their prototype maths games. They also liked working with the team and would all potentially consider taking part in the sessions again. However, the activities that required drawing were highlighted as a potential issue, with some children with ASD expressing a dislike for drawing-based activities and others preferring to use alternative modes of expression when they could. This reinforces the concern within Study One about drawing ability and emphasises the need to provide alternative options for drawing within the design sessions.

Although the children within Study Three were positive about the sessions, there were also issues raised by the children with ASD. The increased demands on their teamwork skills and also the high standards some of the children set themselves within the build task sometimes resulted in frustration and negatively impacted their participation. ToM and E-S theories (Baron-Cohen, 2000b, Baron-Cohen, 2009) predict that these children may experience issues working with others, particularly those of lower abilities, due to difficulties with empathising with other people and recognising that they may not have the same level of understanding of the design task as themselves. Therefore it is important to set the children's expectations during the early sessions to ensure they are realistic, match ability levels of the child participants wherever possible and also provide enough time to allow the children to achieve a satisfactory output.

RQ2c) Does participating in the technology design process benefit children with ASD in any way?

The teaching staff members who participated highlighted a number of skills the children with ASD developed as a result of participating in the sessions including turn-taking, confidence, compromising, teamwork and creativity skills, indicating that the children benefited from their participation. They also suggested the children developed a sense of empowerment as a result of their participation, due to the adults listening to their ideas and seeing these ideas come to life through the computer. Participation within Study Three also enabled them to develop technical skills through building their own prototype games.

7.5.2 Summary

The findings presented within this chapter have highlighted the varying nature of the adult support required by children with ASD during the technology design process, which is dependent on the individual children's needs and can also change over time. One of the key findings was the role and familiarity of the teaching staff member with respect to the children with ASD, and the benefit of the implicit knowledge he/she can provide beyond that of the researchers. The importance of taking into account the children's current ability levels and setting their expectations appropriately at the start of the process as well as allowing the necessary time to produce an acceptable design output has also been highlighted.

One primary outcome of this chapter was the identification of a range of potential benefits of the children's participation within the PD process. As previously stated one of the specific benefits that resulted from the children's participation within the technology design process was the development of teamwork skills. This is something that can be particularly challenging for children with ASD and therefore an area that is worth exploring further to establish the extent the design teams were able to collaborate during the design process and the impact this had on the resultant design contribution. The findings from this analysis are discussed in the following chapter.

Chapter 8 Collaborating within a Design Team

8.1 Introduction

This chapter looks specifically at collaboration within a design team and addresses **RQ3) What factors need to be considered to enable children with ASD to *collaborate* with others during design sessions?** Collaboration is a key part of PD due to a need for participants to work with other stakeholders during the technology design process (Hecht and Maass, 2008). Therefore it is important to establish the ability of children with ASD to collaborate with others within this context and determine if they require any support in order to collaborate successfully. The review of the literature in Chapter Three raised a number of potential issues that children with ASD could experience with regard to collaborating with other design team members. Table 8.1 (initially presented within Chapter Three) highlights the mechanisms that can enable successful collaboration and the typical ASD characteristics that could potentially impact a child's ability to utilise these mechanisms effectively.

As there are a number of potential difficulties impacting the collaboration of children with ASD it is important to establish the extent of this impact within a PD setting. Therefore a number of activities from both Studies Two and Three involving direct collaboration between team members were analysed, to determine the implications for the type and level of the collaboration support provided within the IDEAS method. This chapter reports the analysis of these collaborative activities, focusing on the support the children required in order to collaborate successfully and if any collaborative learning took place as well as identifying specific collaboration difficulties. The findings from this analysis are then discussed in terms of the typical ASD characteristics presented above and implications for the successful involvement of children with ASD within a collaborative design environment.

Mechanisms for successful collaboration	ASD characteristic impacting success
Mutual engagement (Roschelle and Teasley, 1995)	Difficulty maintaining engagement (Mesibov et al., 2007)
Joint attention and decision making (Roschelle and Teasley, 1995, Fleck et al., 2009)	Problems with mindblindness and difficulties with joint attention behaviours. Lack of social problem solving ability. (Mesibov et al., 2007, Wainer et al., 2010, Schreiber, 2011)
Verbal discussion including turn-taking, narration, questions, negotiation and conflict resolution (Roschelle and Teasley, 1995, Pinelle and Gutwin, 2007, Fleck et al., 2009)	Difficulty with reciprocal conversation including turn-taking and staying on topic. Preference for visual over verbal communication. Lack of social problem solving ability (Mesibov et al., 2007, Schreiber, 2011)
Sharing written messages (Pinelle and Gutwin, 2007)	Difficulty understanding written language that includes abstract concepts and also limited development of social behaviours such as sharing (LeBlanc et al., 2003, Mesibov et al., 2007)
Understanding and using gestures (Pinelle and Gutwin, 2007)	Difficulty with joint attention behaviours including eye contact, following gaze and physical gestures (Mesibov et al., 2007, Wainer et al., 2010)
Maintaining basic awareness (Pinelle and Gutwin, 2007, Fleck et al., 2009)	Lack of eye contact, problems maintaining engagement and difficulty with joint attention behaviours (Mesibov et al., 2007, Wainer et al., 2010, Schreiber, 2011)
Interpreting information from objects and other people's bodies (Pinelle and Gutwin, 2007)	Difficulties understanding subtle social rules and behaviours, problems interpreting body language (Mesibov et al., 2007, Schreiber, 2011)
Coordinating resources with others, both verbally and non-verbally (Pinelle and Gutwin, 2007)	Egocentricity and mindblindness difficulties (Frith and de Vignemont, 2005, Mesibov et al., 2007, Lombardo and Baron-Cohen, 2010, Schreiber, 2011)

Table 8.1 Typical ASD characteristics potentially impacting successful collaboration

8.2 Outputs and Analysis

In order to address **RQ3** the digital videos showing the children participating within collaborative activities from Studies Two and Three were analysed. Firstly to identify any collaborative behaviours exhibited by the children, in order to establish their ability to collaborate with others within this context. The same activities were secondly analysed to establish any difficulties with collaboration demonstrated by the children, which are important to identify, as there may be specific areas of collaborative activities in which children with ASD need more support. The approach to this analysis as well as the specific collaborative activities analysed were guided by a number of sub-research questions and are described in more detail below.

RQ3a) Do children with ASD demonstrate any appropriate collaborative behaviours and how does this impact on the success of the design team?

To address this sub-research question firstly a coding scheme based on the collaborative mechanisms defined within the existing collaboration literature was developed. This coding scheme was then applied to the videos of two separate collaborative activities from Study Two as well as the game development activity, which took place during sessions four and five during Study Three. These activities were chosen because they required the child participants to directly collaborate within one another (albeit to varying extents) in order to successfully complete the activity. Any instances of children exhibiting collaborative behaviours were coded using this scheme to establish the impact of their ability to collaborate on the team's success within each activity.

RQ3b) Do children with ASD experience any specific difficulties when collaborating with other team members, what is the cause of these difficulties and how are they resolved?

To address this sub-research question the same coding scheme described above was used to re-analyse the videos and any observed difficulties in relation to these collaborative mechanisms noted in order to identify areas that may require additional support to prevent the occurrence of breakdowns in collaboration, defined as a mismatch between the expectations of one team member and the actions of another (Humphries et al., 2004). Each of these collaboration difficulties was then examined to establish how they were resolved (if at all) and again what impact this had on the team's success within each activity.

8.2.1 Study Two Collaborative Activities

Study Two involved four separate design teams (as initially described in Chapter Five), two teams incorporating three children with HFA/AS aged 12-13 years and two teams incorporating three TD children aged 11-13 years (see Table 8.2 for a summary of the child participants).

Team Name	Child Participant 1	Child Participant 2	Child Participant 3
ASD Team 1	M1 aged 12, VIQ=102	M2 aged 13, VIQ=88	F1 aged 12, VIQ=104
ASD Team 2	M3 aged 13, VIQ=89	M4 aged 13, VIQ=89	M5 aged 13, VIQ=98
TD Team 1	M6 aged 11, VIQ=102	M7 aged 13, VIQ=88	F2 aged 13, VIQ=102
TD Team 2	M8 aged 13, VIQ=91	M9 aged 13, VIQ=96	M10 aged 12, VIQ=98

Table 8.2 - Summary of Child Participants in Study Two

The first collaborative activity examined during Study Two was the structured **Team Building activity**, which took place during session one. This involved the children working together to build a LEGO© Minotaurus game (see Fig. 8.1), which included the build of the maze-based game board as well as the Minotaur game character. During this activity the children were assigned explicit roles, which were activity-specific, inspired by the LEGO© therapy intervention designed to build social skills in children with ASD (Owens et al., 2008). These roles were different to the levels of involvement defined by Druin (2002) previously discussed in Chapter Two. These roles included:

- *Builder*: assembles the bricks
- *Director*: reads out the instructions
- *Supplier*: gets the bricks

For guidance, the children also had clear structured visual instructions, which were communicated to the other children by the *Director*. This activity is an example of a *tightly coupled* collaborative activity (Olson and Teasley, 1996) where the children are directly dependent on each other to complete the activity and are required to closely interact with one another to coordinate the building of the game.

Figure 8.1 – ASD Team 1 building the LEGO© game

The second activity examined was the creation of the **Display of Work**, which took place during the final session (session six) and involved the children working together to produce a paper-based display of what they had achieved over the previous five sessions. This activity still had some structure in terms of the templates the children had to complete, but they were given more freedom in terms of their role within the team. During the session the children could contribute to a number of different areas of the activity through undertaking specific responsibilities. These were different to the roles during the Team Building activity, as they were not explicitly defined and did not persist throughout the activity. These responsibilities included:

- Finding correct images related to session template
- Gluing images on session template
- Writing/drawing answers to template questions
- Arranging template on display board
- Gluing templates on display board (see Fig. 8.2)
- Creating title for display board

This activity is an example of a more *loosely coupled* collaborative activity (Olson and Teasley, 1996) where the children need to be aware of what each other is doing, but some of the work can be undertaken in parallel. However, there are still some responsibilities that are directly dependent on one another such as completing the templates before arranging and gluing them on the display board.

Figure 8.2 – ASD Team 1 working together to assemble their Display of Work

This process was still facilitated by the adults to ensure all children made a contribution. These two activities were chosen as they provide a comparison between a more highly structured collaborative activity (Team Building activity) and a less structured collaborative activity (Display of Work activity) as well as between activities that occurred both early and later on within the design process.

8.2.2 Study Three Collaborative Activities

Study Three involved four separate design teams (as initially described in Chapter Six), two teams incorporating three boys with HFA/AS aged 13-14 years and two teams incorporating three TD boys aged 12-14 years (see Table 8.3). Two of the teams (ASD team 2 and TD team 2) had taken part in the previous study and two were new design teams.

Team Name	Child Participant 1	Child Participant 2	Child Participant 3
ASD Team 2	M3 aged 13, VIQ=89	M4 aged 13, VIQ=89	M5 aged 13, VIQ=98
ASD Team 3	M11 aged 14, VIQ=114	M12 aged 12, VIQ=128	M13 aged 13, VIQ=101
TD Team 2	M8 aged 13, VIQ=91	M9 aged 13, VIQ=96	M10 aged 12, VIQ=98
TD Team 3	M14 aged 13, VIQ=114	M15 aged 13, VIQ=125	M16 aged 14, VIQ=105

Table 8.3- Summary of Child Participants in Study Three

Within Study Three the collaborative activity undertaken during sessions four and five was examined. These sessions incorporated a highly collaborative activity, requiring the children to work together to build their maths game using a single computer (see Fig. 8.3).

Figure 8.3 – TD Team 3 building their maths game on the computer

The children were provided with a wireless keyboard and mouse with which to control the computer and they were responsible for coordinating the access to these devices to allow all team members to contribute to the activity, with the adult providing a facilitation role where necessary. Although the children were not given explicitly defined roles at the start of the sessions, the devices guided the role each child could undertake depending on who was in control of which device and included the following:

- *Keyboard Operator*: Inputs the names of game elements, maths questions asked during the game and any other text to be included within the game.

- *Mouse Operator*: Has overall control of the computer, including which part of game is currently being worked on.
- *Observer*: Can provide verbal input to direct what the other children are doing.

This activity is a more *tightly coupled* collaborative activity (Olson and Teasley, 1996) as the need to coordinate access and input through the devices means the children are directly dependent on one another to manage the implementation of the game.

8.2.3 Mechanisms for Collaboration

In order to identify instances of collaborative behaviours exhibited by the children during the collaborative activities within Studies Two and Three a coding scheme was developed. The coding scheme is based on the mechanisms[2] defined within the existing collaboration literature and refined by applying these existing mechanisms to a sample of the design sessions from Study Two. This was undertaken to determine their applicability to the data within this study and noting any collaborative instances where the existing literature does not provide an appropriate mechanism. The mechanisms were taken from highly cited research papers (see below) within the literature on support for computer-mediated collaborative work. They were chosen because each of these papers provided a clear detailed description of the mechanisms, which would enable them to be used to identify instances of face-to-face collaborative behaviour within a design session. The existing mechanisms used as a basis for this coding scheme include:

- *Categories of Design Meeting Activity* (Olsen et al., 1992): defines a number of design activity codes, which can be used to analyse how groups engage within a collaborative design task. These codes include issue, alternative, criterion, project management, meeting management, summary, clarification, digression, goal and walkthrough.
- *Framework for Analysing Collaboration* (Roschelle and Teasley, 1995): introduces a number of discourse event categories that can be used to guide the analysis of collaborative work. These categories include turn-taking, socially distributed productions, repairs, narrations and language and action.
- *Mechanics of Collaboration* (Pinelle and Gutwin, 2007): these mechanics represent the basic operations of teamwork, which team members are required to undertake to complete an activity collaboratively. The high level categories of these mechanics include explicit communication (verbal and non-verbal), information gathering (including awareness), shared access (to tools, objects and space) and transfer (of resources).
- *Collaborative Learning Mechanisms* (Fleck et al., 2009): these mechanisms represent both the verbal and physical interactions undertaken when individuals collaborate around a table top. These mechanisms encompass those used for both collaborative discussion and also for coordination. The high-level categories of these mechanisms include making and accepting suggestions, negotiating, and maintain joint attention and awareness.

To develop the coding scheme (which can be found in Appendix F) a subset of the transcripts from Study Two were chosen to provide a representative sample across both the ASD and TD teams as well as across two of the different collaborative activities being examined within this study. Each of the children's utterances and actions were coded within an initial framework based on the high level collaboration categories defined by Pinelle and Gutwin (2007) which include Communication (Explicit Communication and Information Gathering) and Coordination (Shared Access and

[2] Within the literature the terms 'category' and 'mechanic' is also used, however for consistency within this thesis the term 'mechanism' is used to refer to categories, mechanics and mechanisms of collaboration

Transfer). As a means of validating the categories a *negotiated approach* to the development of this coding scheme was taken (Garrison et al., 2006). This involves the researchers independently coding the transcripts using the initial coding scheme and then actively discussing the result of this coding in order to come to an agreement where the majority (or all) of the codes are in agreement. Garrison et al. (2006) point out a number of advantages of this type of approach which include that the coders are able to develop a new point of reference to view the collaborative behaviours and also that it controls for simple errors. However, they also raise the issue that the process of these negotiations can alter each individual's approach to the coding process, but that embedding the research questions within an appropriate theoretical framework can help to address these types of methodological issues.

For this work two researchers independently coded a representative sample of the transcripts; one researcher who had participated in the sessions and a second researcher who specialised in collaboration. Each coded utterance/action was individually discussed, if the codes agreed the discussion moved on, but if there was a disagreement the coders discussed their reasons for the code and then attempted to come to an agreement. This resulted in either one coder altering their code to match the other or the coders agreeing on a completely new category, with all disagreements able to be resolved. The majority of these disagreements were in relation to similar types of verbal utterances such as *suggestions*, *clarifications* and *statements* as well as the difficulties in identifying instances where the children were demonstrating an *awareness of others/resources*, particularly for the collaboration researcher who was not present in the sessions. Due to ethical and confidentiality considerations the collaboration researcher was not able to view the actual videos of the sessions and therefore worked solely from the transcripts. These transcripts were made as detailed as possible including all non-verbal interactions, although it is important to note this process is still problematic due to some level of interpretation being required from the transcriber in order to do this. This coding scheme was then refined, with each code category explicitly defined using the mechanisms introduced in the collaboration literature described above as a guide.

Once the final coding scheme had been established a phenomenological approach was taken to the analysis, where one researcher coded the remaining transcripts from all of the chosen collaborative activities in order to identify specific collaboration-related phenomena. This approach was taken due to the fact an independent coder was unable to view the videos from the session. Furthermore, there are many issues in interpreting the intentions of the children's behaviours with regard to collaboration, and therefore a second coder who was not in the session, and did not have the same background in the areas of PD, autism and collaboration may interpret the situation differently. A phenomenological approach allows the presence of factors related to collaboration and their effects to be identified for single cases, but "must be tentative in suggesting their extent in relation to the population from which the participants or cases were drawn" (Lester, 1999). Consequently, it is important to note that the findings within this chapter provide an indication in relation to the collaboration of children with ASD, but further work needs to be undertaken to establish the collaborative abilities within a PD context across the ASD population.

The videos from the collaborative activities from both studies were then reanalysed to identify any difficulties in the collaboration within the team. The analysis employed the coding scheme described above as a guide to help establish if the children experienced difficulties with any particular collaborative behaviour related to the collaborative mechanisms specified within the scheme. Any potential causes for these difficulties were also recorded as well as how the difficulties were resolved (if at all) to enable the team to progress in the activity. The findings from this two-part analysis are described in detail below.

8.3 Study Two Collaboration Findings

The coding scheme described above was applied to the two collaborative activities within Study Two, the **Team Building activity** during session one and the **Display of Work activity** during session six. This was undertaken for each of the four design teams (ASD teams 1 and 2 as well as TD teams 1 and 2) to help in highlighting instances of successful collaboration (**RQ3a**), which is important in establishing the ability of children with ASD to successfully participate within the technology design process using a PD approach. The comparison between the ASD and TD teams also helps to establish if children with ASD require greater or simply different support for collaboration than TD children do.

8.3.1 Study Two Collaboration Successes

This section addresses the following sub-research question **RQ3a) Do children with ASD demonstrate any appropriate collaborative behaviours and how does this impact on the success of the design team?** The results of the coding were firstly analysed to establish any collaborative behaviours the child participants exhibited within each activity, how they were using them and the impact this had on their team's successful completion of the activity. The findings from this analysis are described below, organised by the high-level collaboration categories specified by Pinelle and Gutwin (2007). Each category is divided into ASD team and TD team subsections, with both the findings from the Team Building and Display of Work activities described within each of these subsections. All of the related collaborative mechanisms are shown in italics. The implications of these findings are then briefly discussed at the end of the section and then discussed in more detail within the chapter summary.

8.3.1.1 Verbal Communication – ASD Teams

During the **Team Building activity** the adults were required to facilitate much of initial the verbal interaction between the children within **ASD team 1**. The interaction between the children did increase later in the session though, with M1 leading the build of the Minotaur (a particularly difficult element of the game) by asking M2 direct questions. There was also some evidence of M1 using verbal *narrations* to allow the others to *monitor his actions*, such as "*Ah I have to think because this bit is stuck and I can't get this bit off*". There were some *verbal digressions* away from the activity (see Graph 8.1). Half of the digressions involved one child making a non-task related utterance, but later in the activity these digressions involved two children participating within a social conversation, which indicates that the team building nature of the task may have had a positive impact on the relationships between the children.

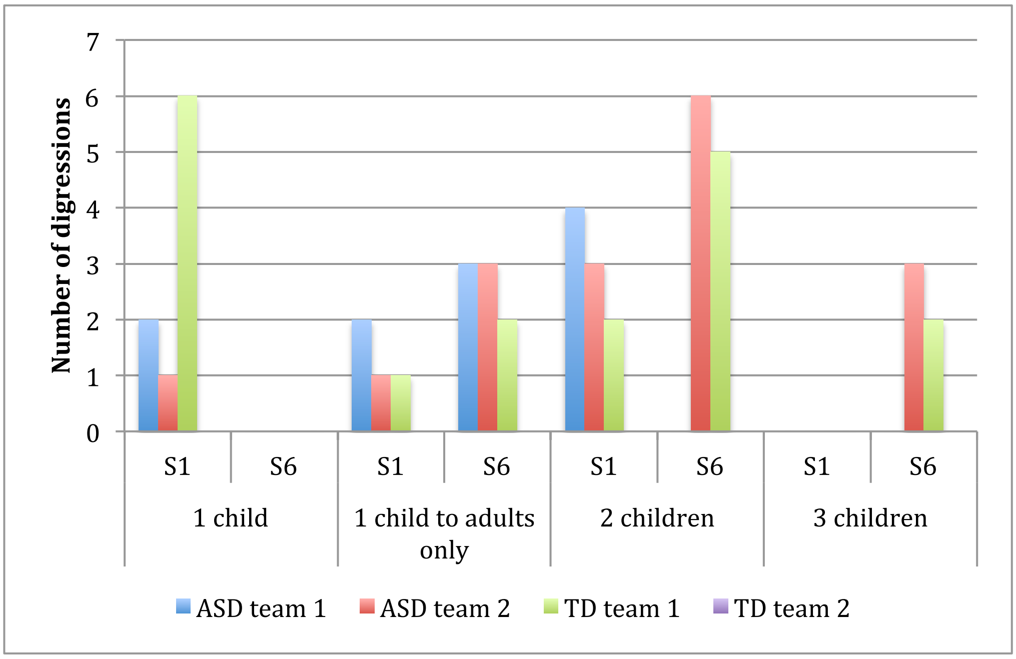
During the **Display of Work activity** there were slightly more different types of collaborative behaviours observed within **ASD team 1**, such as the use of *narrations* by both M1 and F1 to enable other team members to follow what they were doing and direct *verbal discussion* of the resources to help establish a shared understanding. Overall the children appeared more engaged in this activity, with very *few digressions,* with the children only occasionally making a non-task related utterance (see Graph 8.1) and *no adult intervention* required to get them back on task.

During the **Team Building activity** there was much more verbal interaction between the children within **ASD team 2**, with considerably less adult intervention required to facilitate this. M3 sometimes used *narrations* so the rest of the group were *aware* of his actions such as when he checked something in the instructions saying *"It will probably* *tell me in here"*. M3, the child undertaking the director role within this team also gave more explicit *verbal directions* to the other children within the team. There were fewer *digressions* from the task within this team, and the majority of these involved two children participating in a social conversation indicating a stronger bond within the team (see Graph 8.1). The boys were also able to return to the activity with minimal adult intervention.

During the **Display of Work activity** within **ASD team 2** some verbal discussions involving all three children to establish a *shared understanding of the resources* were observed. For example all three boys contributed to the arrangement of the paper templates on the display board:

> *M5: "What about that one in that corner and that one and one in the middle".*
> *M3: "Yeah that would work".*
> *M4: "Yeah".*

Some *limited narration* also occurred, such as M3 making the team aware of the final arrangement of the display board by saying *"That's a basic structure"*. In contrast to ASD team 1 the *verbal digressions* increased within this activity (in comparison to the Team Building activity), with adult intervention required on some occasions to bring them back to task. However, the majority of these digressions involved two or three of the children participating within a social conversation (see Graph 8.1), which again could be a positive indication of the relationships built up within the team.



Graph 8.1 – Number of children participating in verbal digressions during session 1 and session 6

8.3.1.2 Verbal Communication – TD Teams

During the **Team Building activity** there was more verbal interaction between the children within the TD teams. The children within TD team 2 demonstrated little difficulty providing *verbal directions*, but within TD team 1 the child within the director role required more prompting from the adults for giving directions. Within both of the TD teams there was much verbal discussion between the children particularly in order to establish a *shared understanding of the resources* they were referring to. Both TD teams used considerable *narrations*, M6 within TD team 1 often verbally counted out the blocks he was retrieving so everyone was *aware* of the number that was being transferred to the builder and also stated things such as *"I'm gonna put them down there"* so they knew where the blocks were. Similarly within TD team 2 M9 said *"I'll do up to here"* so the others knew what he was planning to do and M8 said *"It's ok, I'm starting to get a bit ahead of you"* to help create a *shared understanding* of the current status of the activity. There were quite a few *verbal digressions* from the activity within TD team 1 (see Graph 8.1), which mainly involved one child making a non-task related utterance and occasionally two children participating within a social conversation. This resulted in some children becoming disengaged from the activity and the adults required to prompt them to reengage. In contrast the children within TD team 2 were highly engaged within the activity and there were no *verbal digressions*, which demonstrated that social conversation was not required to complete the activity successfully as a team.

During the **Display of Work activity** within **TD team 1**, M6 undertook much of the writing and used *narration* so all team members were *aware* of what he was going to write before he did so. There was some verbal discussion to establish a *shared understanding of the resources* in relation to the arrangement of the templates on the display board. Within **TD team 2** there were less verbal utterances made than within the other teams, demonstrating the ability to collaborate in non-verbal ways which indicated a deeper understanding of each other's intentions and of the shared goal. Again the children within TD team 2 were highly engaged within the activity and did not *digress* from it at all, whereas TD team 1 displayed a similar number of *digressions* as the first activity which again sometimes required adult intervention to bring them back to task (see Graph 8.1). However, in contrast to session one these more often involved two or three of the children participating within a social conversation rather than one child making a non-task related utterance, indicating that relationships within the team had been built up over the course of the sessions.

8.3.1.3 Other Communication – ASD Teams

During the **Team Building activity** there were some instances of *deictic gestures* (simultaneously using spoken language and gestures) observed within **ASD team 1**, with M2 pointing towards the board to provide some indication of where to place the block and M1 holding up blocks to confirm he had retrieved the correct one.

During the **Display of Work activity** within **ASD team 1** the use of *deictic gestures* was slightly more frequent, with some children pointing to images to *establish a shared understanding* of what each image represented or to indicate which images related to which session. The children also demonstrated their display board arrangement ideas by changing the layout of the templates, with some of these *gestures* not accompanied by verbal language. This collaborative behaviour was not observed within Team Building activity and indicates that the children may recognise that other team members are able to *maintain an awareness* of their actions without the use of verbal language.

During the **Team Building activity** the children in **ASD team 2** used lots of *deictic gestures* such as pointing at the object they were referring to or to indicate where on the board to place the block, holding up blocks for confirmation and demonstrating where objects should be placed, to help establish a *shared understanding of the resources*.

Again **ASD team 2** used *deictic gestures* during the **Display of Work activity** such as pointing to an image to *establish a shared understanding* or to indicate selection, as well as in demonstrating potential arrangements of images.

8.3.1.4 Other Communication – TD Teams

During the **Team Building activity** both TD teams used *deictic gestures*, pointing at the board, holding up blocks and demonstrating where to place blocks. In contrast to the ASD teams within this activity sometimes the TD children were able to make these *gestures* and be understood by the other children within the team without the need to be accompanied by verbal instructions. This highlights a difference in the sequence of mechanics, as here a gestural mechanic did not need corroboration by another mechanic e.g. a verbal utterance.

In the **Display of Work activity** the children in both TD teams also used a number of *deictic gestures* as well as *non-verbal gestures* again to point to images to *establish a shared understanding* of the images and arrange the templates on the display board.

8.3.1.5 Awareness – ASD Teams

During the **Team Building activity** there was evidence within **ASD team 1** that M1 attempted to establish a *shared understanding of resources* by saying which blocks they had and clarifying which block M2 was referring to.

During the **Display of Work activity** there was more evidence of a level of awareness within **ASD team 1**. For instance the children occasionally *assisted* each other within this activity, with M1 helping F1 to find a missing image and M2 helping her to arrange the paper templates on the display board. The children demonstrated some *awareness of other team members' body language*, recognising when they were waiting to stick an image down on the template and transferring the template to them or moving their body to allow them access to the template.

During the **Team Building activity** within **ASD team 2**, M3 demonstrated that he was maintaining an on-going *awareness* of M5's actions, intervening if he retrieved the incorrect pieces, which ensured that the activity progressed more smoothly.

There was also evidence of this level of awareness being maintained during the **Display of Work activity** when M3 showed an *awareness of other team members' actions* when M5 took one of the templates away to start gluing before the final arrangement had been agreed. M3 retrieved the template from him and explained the arrangement had not been finalised. This ensured that actions that were not unanimous were dealt with at the time instead of causing problems later in the task. Also M3 *verbally shared his ideas* for a potential arrangement as well as the positioning of the title, with M4 moving the corresponding templates accordingly, demonstrating a *shared awareness of the resources* and the ability to *monitor another child's actions*.

8.3.1.6 Awareness – TD Teams

During the **Team Building activity** within both TD teams there was evidence of the children maintaining an *awareness of other's actions*. For instance within **TD team 1** when F2 realised that M9 did not need any more directions for the build, she said "*I think he already knows*". Also within **TD team 2** M8 recognised he was going too fast for the other boys within the team and stated "*It's alright, I'm just starting to get a bit ahead of you*". This contrasted with the ASD teams where adult intervention was required enable the children's awareness of this particular issue. The children within both TD teams also demonstrated an *awareness of other team members' body language*, passing resources when another child had their hand out and switching roles when one team member put different resources in front of them, understanding that they were now responsible for that resource. This helped them make good progress within the task, reducing the amount of time needed for verbal discussions. However, the children within TD team 2 demonstrated better collaboration skills when it came to *providing assistance* to other team members. During the build of the Minotaur, M8 was responsible for communicating and stated, "*I'm confused*". M9 came to his *assistance* helping to look at the instructions, explaining the solution and then relaying it to M10 who was responsible for the actual build. M8 also *assisted* the other children with their separate roles where necessary, helping rather than taking over, as happened within ASD team 2. The children within TD team 1 did occasionally offer each other assistance, but the other child did not always acknowledge this, indicating that they may not have *maintained awareness* throughout the task.

During the **Display of Work activity** the children within **TD team 1** demonstrated a greater awareness of the other team members need for *assistance* offering suggestions when a child was stuck for what to write. F2 also *offered to help* write the title when M6 was concerned about the neatness of his attempt and M7 explained the difference between portrait and landscape to M6, when he was unsure. M6 and M7 were also *aware* of F2's *actions*, when she took one of the templates to start gluing before the arrangement had been agreed and were able to intervene verbally rather than physically to stop her from doing this. Within **TD team 2** the children demonstrated a high level of *awareness* of the other team member's *body language* reacting to each other's hand signals, body movements and nodding of heads, which reduced the need for verbal discussion and enabled them to progress through the task smoothly. They also demonstrated an *awareness of each other's actions* when they took it in turns to write the letters of the title. The evidence of awareness within this team indicates the children had a more advanced level of collaboration ability, which helped them to complete the task quickly and efficiently.

8.3.1.7 Coordination – ASD Teams

During the **Team Building activity** within **ASD team 1** there was an example of loosely coupled collaboration, where one child's actions weakly affected another child, when M1 directly asked questions to M2 about how to build a particularly difficult element of the game. However, in general there was little evidence of an ability to *coordinate actions* within this team, which may have had an impact of the number of collaboration difficulties discussed in the following section. The children did demonstrate a limited ability to *coordinate resources* through the transfer of the bricks between the supplier and builder.

There were occasional instances of coordination during the **Display of Work activity**. For example when the templates did not fit in properly within the arrangement suggested by F1 and the children instead were able to *coordinate their actions* and work together to change it into line with M1's arrangement suggestion. M1 also moved out of the way to allow F1 to glue her image on the display board. They occasionally were able to coordinate the *transfer of resources* between team members unprompted when it was required by another team member. This shows a slight increase in the variety of coordination-related behaviours within the team from session one, not guided by the adults, which may have been developed over the design process.

During the **Team Building activity** two of the boys within **ASD team 2**, M4 and M5, demonstrated the ability to work together on the task of completing the final stages of the build of the game. This is an example of tightly coupled collaborative behaviour. M4 explained to M5 what was left to do and they were able to *coordinate their actions* to complete the build successfully. The children also demonstrated they were able to *coordinate resources* through the transfer of the bricks between the supplier and builder.

There was less evidence of this *coordination* during the **Display of Work activity**, which could potentially be due to the less structured nature of this activity. The children were only able to *transfer resources* between themselves when prompted by an adult.

8.3.1.8 Coordination – TD Teams

During the **Team Building activity** the children in the TD teams again demonstrated the ability to *coordinate resources* through the transfer of the bricks between the supplier and the builder. Within **TD team 2** M9 showed he was able to *coordinate his actions* with the other two boys, transferring between assisting the supplier and the builder within their roles to enable the build to proceed more efficiently. The children also swapped roles throughout the activity, ensuring every child had an equal opportunity to undertake each role and were the only team to do this.

During the **Display of Work activity** the children in both TD teams demonstrated the ability to *coordinate the resources* by transferring them between each other unprompted when they recognise another team member had a need for it and also to ensure they took turns accessing the resources. They were able to *coordinate their actions* successfully, both using *verbal discussion* and also by reacting to the *body language/physical gestures* of other team members such as holding out a hand to indicate that they wish something to be passed to them or allowing access to the template when someone was waiting to stick an image on it. Within **TD team 1** F1 also subtly *dictated the responsibilities* for the remaining templates passing the glue sticks and paper templates between the boys to indicate what their role should be. She used this collaborative behaviour to subtly avoid having to do any writing, which she expressed a dislike for during the activity. Within **TD team 2** little *narration* was used and the children demonstrated the ability to *coordinate many of their actions non-verbally* by establishing the routine of sharing all tasks at the start of the session and passing resources between themselves to indicate a change in roles. The two boys within TD team 2 *coordinated their actions* to smoothly write and stick down images on the template concurrently, jointly gluing of a single paper template when there was an odd number of templates to glue and also alternating writing letters for the title to ensure equality of work. This again highlighted the advanced collaborative behaviours of the children within these team.

Observed Collaborative Behaviours	**ASD Team 1**		**ASD Team 2**		**TD Team 1**		**TD Team 2**	
	S1	S6	S1	S6	S1	S6	S1	S6
Use of narrations	✓	✓	✓	✓	✓	✓	✓	
Verbal discussion to establish shared understanding of resources		✓	✓	✓	✓	✓	✓	✓
Use of deictic gestures	✓	✓	✓	✓	✓	✓	✓	✓
Use of non-verbal gestures		✓			✓	✓	✓	✓
Evidence of monitoring others' actions			✓	✓	✓	✓	✓	✓
Awareness of others' body language		✓			✓	✓	✓	✓
Provide assistance to other team members		✓				✓	✓	
Coordination of resources	✓	✓	✓		✓	✓	✓	✓
Coordination of actions		✓	✓	✓		✓	✓	✓

Table 8.4 – Types of collaborative behaviour observed during Session 1 and Session 6

Table 8.4 above provides a summary of the different collaborative behaviours observed during the collaborative activities undertaken by the design teams during session one and session six. Overall the children within the TD teams exhibited many different types of collaborative behaviour during both of the activities. However, the number of different collaborative behaviours used within the ASD teams was lower, particularly during the Team Building activity in session one. It is possible that this could initially be due to unfamiliarity with participating within this type of collaborative design environment as well as with some of the other team members. There was evidence that the number of different collaborative behaviours by ASD team 1 increased during the Display of Work activity in session six. The teaching staff member who participated in this team also stated within the survey she completed after the sessions that the children learned to "wait and take turns in conversations" as well as "compromise" ideas. These findings indicate that there may be a greater need for additional support for collaboration from the adults and also a need to provide greater structure within the collaborative activities that occur earlier in the design process.

Within ASD team 2 the number of different collaborative behaviours was similar between the two sessions, although they demonstrated a greater level of collaboration initially than ASD team 1. There was no evidence of the coordination of resources within this team during session six (which was evident during session one), with an adult having to manage this coordination. This may be due to the fact the coordination of these resources was made more explicit during the Team Building activity through the role definitions and visual instructions guiding the activity. This highlights a potential need for increased adult support during less structured collaborative activities. There were more digressions within this team during session six, however these digressions are not always disadvantageous to the collaboration, as these social conversations may have helped to build team bonds. Within ASD team 2 the fact that two or three children participated within the majority of these digressions during session six indicates that there may have been an increase in the team bond from session one.

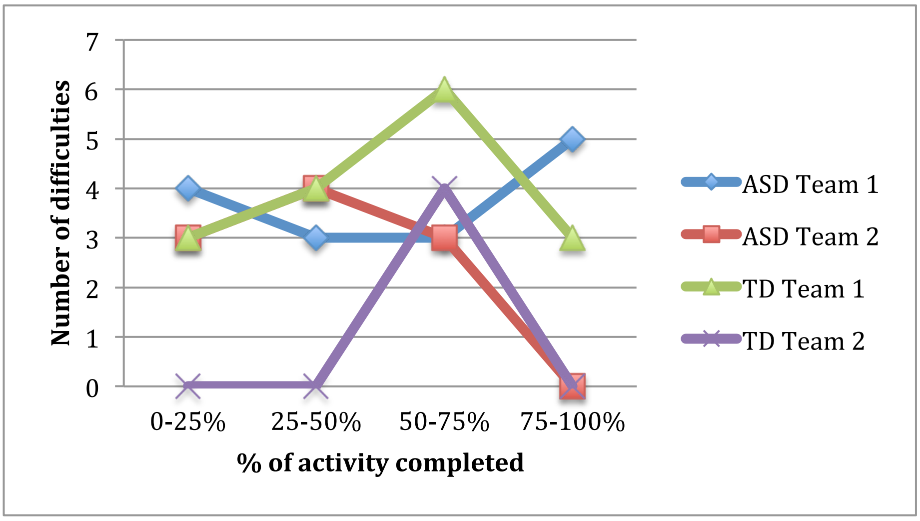
Overall these findings indicate that children with ASD can demonstrate a number of different collaborative behaviours, which may help them to successful participate in the technology design process as part of a design team. However, there were also a number of collaboration difficulties that were observed, which are explored in the following section.

8.3.2 Study Two Collaboration Difficulties

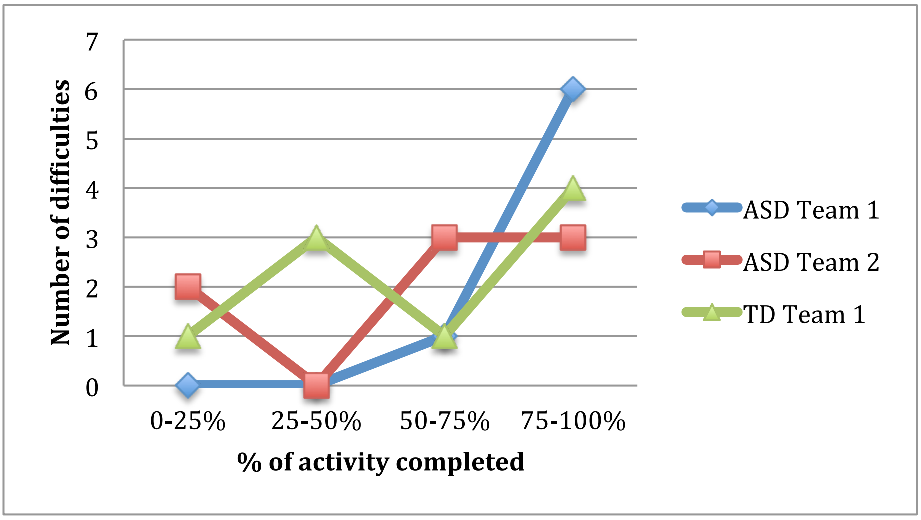
This section addresses the following sub-research question: **RQ3b) Do children with ASD experience any specific difficulties when collaborating with other team members, what is the cause of these difficulties and how are they resolved?** The identification of difficulties is important as if these difficulties remain unresolved then these may lead to breakdowns in collaboration and disruption to overall the design task. Learning to deal with these difficulties is an important part of collaboration (Roschelle and Teasley, 1995), however it is not know if children with ASD are able to recognise these difficulties and establish ways to resolve them without additional support. The two collaborative activities within Study Two, the Team Building activity during session one and the Display of Work activity during session six, were re-examined to identify any collaboration difficulties. Any utterance or action from a child participant that had the potential to negatively impact the collaboration within the team and was associated with one of the collaborative mechanisms defined within the coding scheme was counted as a difficulty (even if this negative impact did not occur or was not observable). Each of these collaboration difficulties was noted down, along with the collaborative mechanism it violated as well as where within the activity this difficulty occurred and how it was resolved (if at all). Collaboration difficulties were identified within all activities within each team except for the Display of Work activity undertaken by TD team 2. The findings from the analysis are discussed in more detail below.

8.3.2.1 Frequency of Collaboration Difficulties

The frequency of the difficulties during both sessions is shown in Graphs 8.2 and 8.3, which show the number observed within each period of the activity. These graphs are intended to show approximately at what point within the activities each of the difficulties occurred, however it is important to note that the teams could have taken different amounts of time to complete specific elements of the activity and therefore may not necessarily be directly comparable between teams. The teams all took approximately 20 minutes to complete the Team Building activity during session one and 25 minutes to complete the Display of Work activity during session six, with the exception of ASD Team 1 who took approximately 30 minutes.



Graph 8.2 – Frequency of collaboration difficulties during Session 1



Graph 8.3 – Frequency of collaboration difficulties during Session 6 (excluding TD Team 2 who did not incur any difficulties)

These graphs show that during the Team Building activity the most difficulties occurred within ASD team 1, but during the Display of Work activity there were actually more difficulties within TD team 1 (followed closely by ASD team 1 and then ASD team 2). This is surprising, as it would be predicted that the ASD teams would have the most difficulties with collaboration, but these findings indicate that TD children can also struggle. However, these difficulties are often related to conflicts between team members which can be an inevitable part of collaboration (Roschelle and Teasley, 1995), therefore having the ability to resolve these conflicts is also an indication of collaboration ability. In contrast the number of collaboration difficulties within TD team 2 was much lower (with *no collaboration difficulties* during session six). This suggests that the individual characteristics of the children could have a significant further impact on the likelihood of collaboration difficulties and conflicts occurring within the team in addition to, or regardless of, whether or not the children have an ASD diagnosis. It should also be noted that during session six TD team 2 only had two children participating in the activity and this may have made the collaboration easier, thus reducing the likelihood of collaboration difficulties.

Graph 8.3 shows a peak in the number of collaboration difficulties later in the session, this corresponds with the building of the most difficult element of the game, where the children struggled to understand and verbally explain how this should be done resulting in frustration and a need for adult intervention. There is also a noticeable peak in difficulties in ASD team 1 towards the end of the sessions. During session one this was due to one child rushing to finish the task and disrupting the coordination between the team members. During session six this was due to the increased need for the children to coordinate the resources and their actions, which relied on the ability to verbally negotiate any differences of opinion, something that the team struggled with. This may indicate a difficulty with tightly coupled tasks and a potential need to provide additional support for these types of tasks.

8.3.2.2 Types of Collaboration Difficulties

Examining these difficulties in closer detail it was established that they fell into five of the collaborative mechanism categories, which included: difficulty with *verbal communication*, difficulty with *negotiation* (disagreements*),* difficulty with *maintaining awareness* (disengagement), difficulty with *coordination* and a lack of *encouragement* (unconstructive criticism).

	Reason for Difficulty	**ASD Team 1**	**ASD Team 2**	**TD Team 1**	**TD Team 2**
Session 1: Team Building activity	Difficulty with Verbal Communication	**6**	**5**	**4**	**3**
	Disengagement	**5**	**2**	**5**	**0**
	Difficulty with Coordination	**4**	**3**	**5**	**1**
	Unconstructive Criticism	**0**	**0**	**2**	**0**
Session 6: Display of Work activity	Difficulty with Verbal Communication	**1**	**0**	**0**	**0**
	Disagreements	**2**	**1**	**0**	**0**
	Disengagement	**1**	**3**	**5**	**0**
	Difficulty with Coordination	**1**	**3**	**2**	**0**
	Unconstructive Criticism	**2**	**1**	**2**	**0**

Table 8.5 – Reasons for Collaboration Difficulties

Collaboration Difficulties during Team Building Activity

Table 8.5 shows that during the Team Building activity the majority of the collaboration difficulties were related to issues with *verbal communication*. This was predominantly in relation to the challenges faced by the child undertaking the director role in explaining to the builder how to put together certain elements of the game. Within ASD team 1 M2 struggled with *verbally communicating* the more difficult instructions and wanted to give up, requiring lots of encouragement and support from the adults to keep him engaged in the activity. Within ASD team 2 M3 demonstrated difficulty in *verbally communicating* what the exact issues with the build were and also struggled directing the more complicated build of the Minotaur. Instead he attempted to directly retrieve the resources himself and take over the build rather than verbally explain. This was a difficulty related to the complexity of the task rather than not wanting to communicate, but this highlights the potential implications if specific elements of a collaborative activity challenge the communication skills of children with ASD potentially requiring additional adult support.

Within TD team 1 F2 also struggled to explain correctly how to build the Minotaur, resulting in M7 attempting the build himself. F2 recognised he was doing it wrong, but instead of offering help directly to him she simply informed the adults that *"he is doing it wrong"*. There were instances of the children within TD team 2 struggling to *verbally communicate*, but to a lesser extent. These findings demonstrate that there is a need for adult support when a collaborative activity becomes more complex or challenging for the child participants, and this need for support may also apply to some TD children as well as children with ASD.

The difficulties in *verbal communication* also had an impact in other areas within both ASD team 1 and TD team 1. The child who was struggling to communicate sometimes became frustrated and *disengaged* from the task this caused *coordination* issues within TD team 1, which resulted in the child undertaking the builder role bypassing the other children and proceeding with the task on his own. The frustration of the child within ASD team 1 also led him to rush through the instructions towards to end of the session, disrupting the *coordination of the actions and resources* between the other team members who struggled to keep up. This highlights a need for adult support to provide encouragement to the child who is experiencing difficulties to stay on task to prevent this becoming a breakdown.

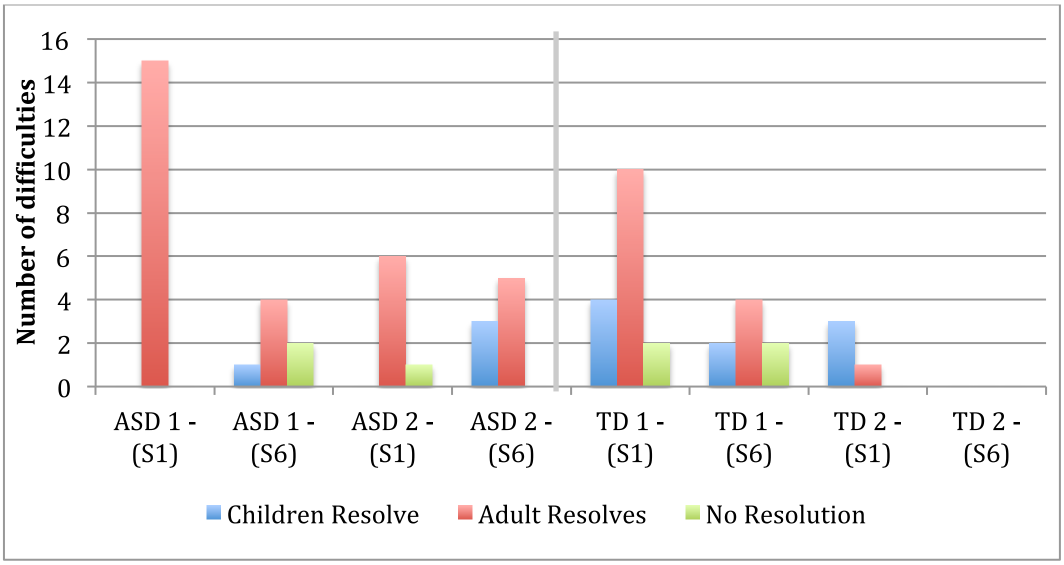
Collaboration Difficulties during Display of Work Activity

Table 8.5 clearly demonstrates that there were less overall collaboration difficulties during the Display of Work activity. One of the most common reasons for collaboration difficulties was due to the *disengagement* of one or more of the children from the task within both ASD team 2 and TD team 1. However, within both teams this was often due to becoming distracted by another child engaging them in social conversation, which indicates the building of relationships between certain children. Although this may be viewed positively in some situations if one child is excluded from the conversation or it disrupts the activity then this can negatively impact the team's overall success.

There were also collaboration difficulties in the *coordination of resources,* for instance within ASD team 1 there was evidence of difficulties with *coordinating resources* when one boy took a template another boy had claimed responsibility for. There were difficulties within ASD team 2 *coordinating resources* when M3 retrieved the template back from M5 when he believed they had not yet agreed on the placement of the templates. Also within TD team 1 one of the children rushed ahead during the gluing activity disrupting the *coordination of the resources* within the activity. These issues all occurred during a tightly coupled element of the activity when the children had to work together to assemble the display of work, further highlighting the increased likelihood of difficulties with coordination to be experienced in highly coupled collaborative tasks and potential need for additional support.

8.3.2.3 Resolution of Collaboration Difficulties

The collaboration difficulties discussed above resulted in three different outcomes, either the children were able to resolve the difficulty themselves, one of the adults intervened to provide a solution to the difficulty or the difficulty was simply ignored by the children and the team moved on without coming to a resolution. Graph 8.4 shows the frequency that each outcome occurred within each team during each session.



Graph 8.4 – Outcome of Collaboration Difficulties

Within the ASD teams and TD team 1 adult intervention was required to resolve the majority of the collaboration difficulties. In contrast the children in TD team 2 managed to resolve the majority of the difficulties during session 1 themselves, with an adult only intervening on one occasion. For example if one child was struggling to verbally communicate the build instructions another child would intervene and assist them in this explanation:

M8: "Yeah and then you need..that thing [pointing at piece] [inspects instruction book further] I'm confused"
M9: "What that bit?"
M8: "Yeah but then.."
M9: "Then you got that bit and then we need to have this one.."

This indicates that the children within TD team 2 may have inherently found collaboration easier than the children in the other teams.

Within ASD team 1 the adults were required to resolve all of the collaboration difficulties during session one and this was similar within ASD team 2, but there was one occasion when a child expressing a disagreement with the role assignments was simply ignored and the other children continued with the activity. This did not appear to negatively impact the activity as this child engaged within his original role throughout the remainder of the session. However, it is difficult to establish exactly what the impact not resolving these collaboration difficulties may have on the team's overall collaboration, as being ignored by other team members, for instance, may reduce the child's motivation to make further contributions to the activity. Across both the ASD teams and TD team 1 during session one adult was required to encourage the children to reengage in the task and to slow down certain children who were rushing ahead of the other team members disrupting the coordination of the task. They were also required to support children struggling to verbally communicate directions to the other team members by providing verbal prompts and asking direct questions to aid their explanations. For example within ASD team 1:

Adult: "Yeah so which bit does F1 need? Can you describe it?"

During session six there were a limited number of instances of the children resolving the collaboration difficulties themselves, for instance when M3 criticised M4:

> *M4: "The big idea..and then we changed the big idea and made it the big big idea..which we also changed to the big big big idea"*
> *M3: "M4 I think you're making crap up now"*
> *Adult: "M3!" [disapproving]*
> *M4: "I don't mind that"*

This indicates a reduced reliance on the adults to facilitate the collaboration between the children with ASD and again highlights a need for additional support during early sessions. Though there is still a clear need for a certain level of adult support throughout all collaborative activities.

There were also a limited number of difficulties within the ASD teams and TD team 1 which were not resolved. This predominantly occurred when one child criticised another child in an unconstructive way, which was ignored by that child. Although this did not have a noticeable impact on the collaboration within the team, it may have negatively impacted the relationships between team members. This also may affect the children with ASD differently to the TD children, as they may be less concerned about other children liking their ideas or suggestions.

The findings from the analysis of the collaboration difficulties during the collaborative activities within Study Two demonstrate that although there were a number of collaboration-related issues within the ASD teams, similar problems also occurred between some of the TD children. There was a clear reduction in the number of collaboration difficulties between session one and session six. There was also some limited evidence that the need for adult intervention to resolve these difficulties was reduced. However, this intervention was still necessary for the majority of the collaboration difficulties, particularly for the tightly coupled elements of the task. Therefore it may be possible for some collaborative learning to occur in children with ASD through participating in the technology design process as part of a design team, but adult support for collaborative activities would be necessary throughout to ensure the children are able to progress after experiencing difficulties in their collaboration.

8.3.3 Study Two Collaboration Implications for IDEAS Method

The findings from the analysis of the collaborative activities within Study Two have a number of implications for the IDEAS method, which include:

- The reduced number of different collaborative behaviours within the ASD teams during the activity at the start of the design process indicates a need for more highly structured collaborative activities and greater adult support during early design sessions.
- The difficulties exhibited by some children with ASD during the less structured Display of Work activity suggests that adults may need to be to provide additional guidance for children with ASD during less structured collaborative activities.
- The higher number of collaborative difficulties observed within the ASD teams during more tightly coupled elements of the activity implies a need for adult facilitation to prevent any breakdowns in the collaboration within the team and continued progression within the activity.
- The higher number of collaborative difficulties observed within the ASD teams during the more complex elements of the activity indicates a requirement for adults to provide strategies or possible solutions for the children as well as

providing encouragement to motivate the children to maintain engagement within the activity.

In order to further build on these findings the collaboration during the game development activity undertaken during Study Three has additionally been analysed, as this is a more tightly coupled and complex collaborative activity than the activities examined within Study Two. The findings from this analysis are described and discussed within the following section.

8.4 Study Three Collaboration Findings

The coding scheme developed during Study Two was applied to the two game development sessions (session four and five) within Study Three for each of the four design teams (the existing design teams from the previous study ASD team 2 and TD team 2 as well as two new design teams ASD team 3 and TD team 3). ASD team 1 and TD team 1 did not participate within this study. These sessions were chosen due to the highly collaborative activity of building the maths game prototype that the sessions involved. Again this was undertaken to help highlight instances of successful collaboration, to establish the ability of children with ASD to collaborate within a design team and where children with ASD may require additional or different support to TD children. This analysis builds on the analysis reported in Study Two by focusing on a more tightly coupled and complex collaborative activity, which was undertaken over multiple sessions. The results of this coding were then analysed to establish the collaboration successes and difficulties experienced by the children during this activity. The findings from this analysis are discussed in the following subsections.

8.4.1 Study Three Collaboration Successes

This section addresses the following sub-research question **RQ3a) Do children with ASD demonstrate any appropriate collaborative behaviours and how does this impact on the success of the design team?** The results of the coding were firstly analysed to establish any collaborative behaviours the child participants exhibited within the game development activity, how they were using them and the impact this had on their team's successful completion of the activity. The findings from this analysis are described below, again organised by the high-level collaboration categories specified by Pinelle and Gutwin (2007). Each category is divided into ASD team and TD team subsections, with the findings from the game development activity described within each of these subsections. All of the related collaborative mechanisms are shown in italics. The implications of these findings are then briefly discussed at the end of the section and in more detail within the chapter summary.

8.4.1.1 Verbal Communication – ASD Teams

Within **ASD team 2** M3 used *narrations* right from the start of session four, which enabled the other team members to follow what he was doing, for example *"Ok let's see…paint a new sprite…so that was a good suggestion so I'm just trying to figure out how to get this bigger so I can focus on that"*. Later during session four M4 also began to use narrations in a similar way. The children were generally quite positive about each other's ideas and suggestions; sometimes *verbally encouraging* the other child *"It's a bit smarter than anything I would have done"*. Although there were also occasions when they did not agree with or like another child's ideas, on some of these occasions the children were able to *compromise* and accept ideas, which they did not initially agree with. For instance when M3 disliked a particular graphic he agreed that it could be included within the game if it was made smaller. Within this team the children demonstrated the ability to verbally *negotiate*, for example on establishing how a certain build task would be divided between them:

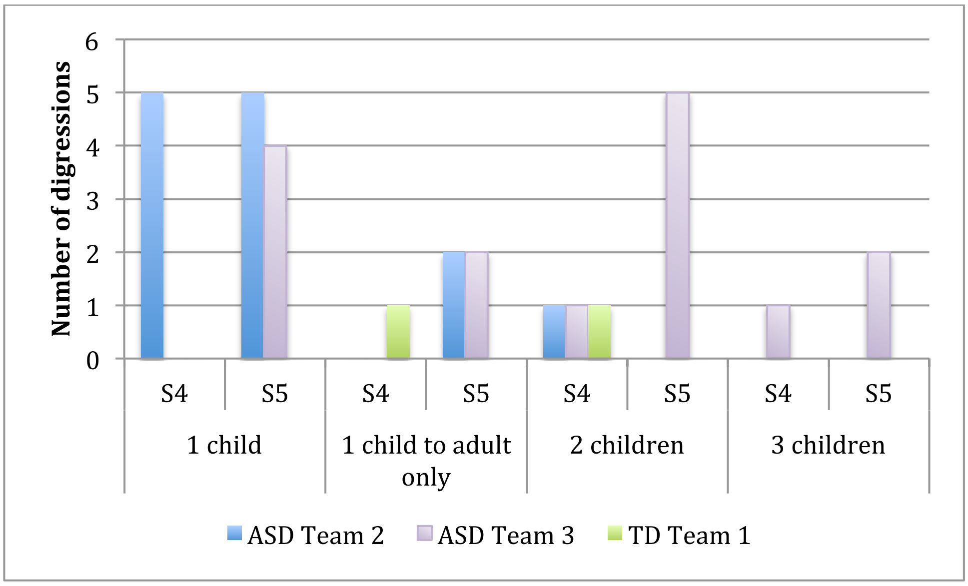
M3: "Ok...do you mind if I do that because I want to make a background thing"
M4: "Erm ok"
Adult: "Are you sure M4...because you wanted to put in the smiley face"
M4: "Ok M3 you do half and I'll do half"

There were a number of *verbal digressions* with ASD team 2 (see Graph 8.5), the majority of which were one-off non-task related utterances made by one child, sometimes repeating the same phrase which is an example of repetitive behaviour associated with ASD. There were also digressions when M3 would discuss topics related to his special interest in computer games with the adults, whilst M4 was in control of the computer. There was only one instance of both children participating within the digressions and therefore these digressions would not have been useful in terms of building the relationship between the child participants.

Within **ASD team 3** it was typically M11 that used *narrations* like *"I find it absolutely stupid...so that's the final thing...I'm just going to put it over here*". Although this would inform the other children what he was doing he often would not explain why, meaning there was little benefit to the collaboration and instead it reinforced his dominance within the task. This was evident on a number of occasions when M13 would question what was happening or express his confusion; such as *"I don't know what is going on but oh well*". M11 would rarely acknowledge these concerns or only provide a short impatient explanation, leaving it to the adults to explain what was happening. During session four there was evidence of the children *encouraging* one another by praising each other's idea, making utterances such as *"Cool, sounds like a good idea to me."*. However, this verbal encouragement did not occur during session five, when the children became increasingly frustrated with one another due to the greater difficulty of the task. *Negotiating access* to the resources sometimes required adult intervention to ensure all of the children had a turn in control of the devices. However, the children also demonstrated they had the ability to *negotiate this access* amongst themselves:

M13: "Give me the mouse M12 and I'll do it" [takes mouse]
M11: "No no M12 gets the mouse now"
M13: "Ok you get the mouse now" [passes mouse to M12]
M11: "And then after we swap M12 since he hasn't not done anything"

There were also a number of *verbal digressions* within ASD team 3, although in contrast to the other ASD team these typically involved two or three of the children within the discussion (see Graph 8.5). Therefore while this could cause the children to become distracted from the activity it could also help build up the bond within the team.



Graph 8.5 – Number of children participating in verbal digressions during session 4 and session 5

8.4.1.2 Verbal Communication – TD Teams

The children in the TD teams used *narrations*, but less so than within the ASD teams. This was because they would generally discuss what they were going to do next as a team and then one child would proceed with implementing what they had agreed, seeking verbal confirmation as they went. Additionally other team members would direct the child in control of the mouse, explaining to them what they should be implementing and how. There was less of a difference in the technical ability of the children within the TD teams than the ASD teams and therefore the children were generally able to follow along with what the child in control of the mouse was doing. The use of *socially-distributed productions* (completing the sentence or idea of another team member) was evident within both TD teams, for instance:

> *M9: "We need to stick to the colour at the bottom, so even if you do fall off then…"*
> *M8: "…it doesn't like put you down right at the bottom"*

This highlighted the similarities in their thought processes, which resulted in a flowing discussion. The TD children were predominantly very positive about each others' ideas, *encouraging and praising* other team members work *"That looks great, that looks really good"*. There were a few *disagreements*, but they were able to sensibly discuss certain elements of the game, with each child making suggestions, *negotiating* ideas and coming to a universal agreement before proceeding with the implementation. As with the ASD teams, some of the TD children needed to *physically demonstrate rather than verbally explain* certain instructions or ideas, although the transition of the devices between the children was smoother and the child demonstrating typically gave the device back unprompted to the first child, which did not always happen within the ASD teams. This indicates that due to the complex instructions/ideas the children were trying to communicate there may have been a need for a physical demonstration to ensure the other children understood and this was not solely due to difficulties associated with ASD. There were very few *digressions* within the TD teams, and TD team 3 did not digress once during either session, potentially indicating their high level of engagement in the activity (see Graph 8.5).

8.4.1.3 Other Communication

Children within all of the teams were observed using *deictic messages,* which allowed them to focus the other children's attention on the area of the computer screen or paper-based interface they were referring to. In contrast non-verbal g*estures* were rare, and therefore may have not been that useful within this particular type of collaborative activity.

8.4.1.4 Awareness – ASD Teams

The children within all of the teams appeared generally engaged and *maintained awareness* throughout the sessions, making comments based on what another child was doing on the computer screen. Within **ASD team 2** M3 helped M4 to *maintain awareness* of what he was doing using narrations *"So I should be able to move him around...yeah look here he goes...look M4 our creation"*. There was occasional *awareness of body language*, for instance when M3 recognised M4 wanted to take control of the mouse and he removed his hand so M4 could take it. There was also evidence of the children demonstrating an *awareness of a need for assistance*. During session four and five M3 assisted M4 on a number of occasions, as he had a more advanced understanding of the Scratch functionality. For example when M4 hesitated and did not know what to do next, M3 said: *"Ok press green...green flag that should like test it out"*.

Within **ASD team 3** there were some instances where the children demonstrated an *awareness of M12's negative body language*, with M13 commenting *"M12 with this head down"* and M11 saying *"M12 come on this one isn't that bad it's better than the Oasis one for this game"*. This indicates that the children could recognize this body language as a sign of boredom or frustration, but frequently chose to simply ignore it and carry on with what they were doing rather than attempting to include the disengaged child. The children recognized a need for *assistance* with M11 providing the most assistance, allowing him to still give input when he was not in control of the mouse. He provided this assistance in a very directive way, which although accepted by the other boys again reinforced his dominance within the team. The others did occasionally attempt to assist M11 but this was frequently rebuffed or ignored because he thought he knew better. However, on one occasion he accepted assistance from M12 when he was trying to use the calculator to determine answers to the maths questions:

> *M12: "Just drag it over here…M11 just drag it over here"*
> *M11: "Actually yeah that's useful, if I put the calculator over here and do cos of 1"*

8.4.1.5 Awareness – TD Teams

The children within the TD teams were able to *maintain awareness* and engagement throughout, even when they were not in control of the computer, which was indicated by their continuous focus on the computer screen and numerous verbal task-related contributions. This was partly facilitated by the child currently in control stopping at various points in the implementation to check that everyone was happy with what they had done before proceeding. There was also more evidence of an *awareness of body language,* where within both teams the children were able to transfer control between them with no verbal discussion. The children recognised when another child wanted to take over the mouse from their body language and would sit back to allow them to access the device. The children were also able to recognise this body language as a sign they were free to take control of the device. The children also *assisted* each other throughout by verbally directing the child who was currently in control of the mouse.

8.4.1.6 Coordination – ASD Teams

The *coordination of the resources* was typically done in a very concrete way within the ASD teams, with the children verbally discussing responsibility for the input devices during the sessions. The children with ASD were able to *manage access* to the devices and *turn-taking* verbally between them to a certain extent. Within **ASD team 2** the children would sometimes discuss who was going to do the next task between themselves or with the adults, or state that they were going to do the next task, before taking control of the mouse. They would also generally ask the child currently in control of mouse if they could take over before attempting to retrieve it. For example:

> *M3: "Do you mind if I do that?"*
> *M4: "Yeah"*
> *Adult: "You do mind?"*
> *M4: "Yes I do.."*
> *M3: "Ok.." [gives mouse back to M4]*
> *M4: [laughs] "no no you do it...come on M3"*

The children in ASD team 2 occasionally demonstrated the ability to *coordinate the resources non-verbally* where one child would reach for the mouse and the other child would allow them access or deposit the device in the shared space for the other child to retrieve. The coordination of the resources mainly revolved around access to the mouse, and the keyboard was left in the shared space for either child to access. This was explicitly defined at the start of session five when M3 said "*Let's just put the keyboard so that the two of us can access it*". The children also demonstrated the ability to *coordinate their actions*, when they worked together to build certain elements of the game that required both mouse and keyboard control, each child taking control of one device and coordinating their input verbally.

Within **ASD team 3** the children demonstrated the ability to manage the *turn-taking* themselves to a certain extent. This was typically done by M11 instructing the other children to give him or another child a device. Assigning the control of each input device was extremely important within this team and the children explicitly assigned these roles:

> *M13: [takes mouse] "I'll have a go."*
> *M11: "Alright I'll do typing."*
> *M13: "And then after that I'll have that back."*
> *M12: "And then I'll do the mouse again."*
> *M11: "No M12 does typing next and I take mouse."*
> *M13: "Yeah and I'm just the one that's just spare."*

There were also instances of one child taking a device from another child, sometimes stating that they would be doing the next task first. Having responsibility for one of the devices helped the child maintain engagement in the session even when they were not required to use it. The children within ASD team 3 were able to *coordinate their actions* on occasions, when the children in control of the mouse and the keyboard were able to work together to build certain elements of the game.

8.4.1.7 Coordination – TD Teams

Within the TD teams the *coordination of resources* was less problematic. The adults were not required to intervene in the *turn-taking*, with the children seemingly aware of ensuring everyone had an equal opportunity to control the mouse. This was done verbally by one child asking another child it they wanted to take over, directing another child to take the next turn, asking to take over or passing the device to a child they believe can do a better job of the current task, saying for example *"There you go M14, you're quicker than me"*. There were also occasions when access was coordinated non-verbally with one child moving a device to another child to indicate they should take over or indicating they wanted to demonstrate something with the mouse through their body language and the other child allowing them access. Within both the TD teams the keyboard was left in the shared area to allow access to all team members, rather than assigning one child responsibility for it. The TD children were able to *coordinate their actions*, with the children coordinating their interaction with the two input devices smoothly.

Observed Collaborative Behaviours	ASD Team 1	ASD Team 2	TD Team 1	TD Team 2
Use of narrations	✓	✓	✓	✓
Encouragement	✓	✓	✓	✓
Ability to negotiate	✓	✓	✓	✓
Use of socially-distributed productions			✓	✓
Use of deictic gestures	✓	✓	✓	✓
Evidence of monitoring others' actions	✓	✓	✓	✓
Awareness of others' body language	✓	✓	✓	✓
Provide assistance to other team members	✓	✓	✓	✓
Coordination of resources	✓	✓	✓	✓
Coordination of actions	✓	✓	✓	✓

Table 8.6 – Types of collaborative behaviours exhibited during the game development activity

Table 8.6 shows that overall the children within the TD teams demonstrated a high number of different collaborative behaviours during the game development activity. Interestingly the ASD teams also exhibited many of these collaborative behaviours, but not as consistently as the TD children. The one type of collaborative behaviour that was solely observed within the TD teams was socially-distributed productions, which are where a child completes the sentence or idea of another team and help to construct and verify shared knowledge member (Roschelle and Teasley, 1995). This collaborative mechanism requires more advanced collaboration skills, as the child needs to monitor the other child's actions and intentions as well as have the ability to reflect on what the other person is thinking about. However, the development of this ability to reflect on another person's thoughts and feelings (theory of mind) is often delayed or impaired within children with ASD (Baron-Cohen, 2000b), and therefore it would be expected that children with ASD would find it very difficult to use socially-distributed productions. This indicates that the construction of new pieces of shared knowledge about the design task may be problematic for children with ASD and an area that would require additional support from the adults. One of the key issues was maintaining good collaborative behaviour throughout each session, particularly when they were not in direct control of the computer or the task became more difficult.

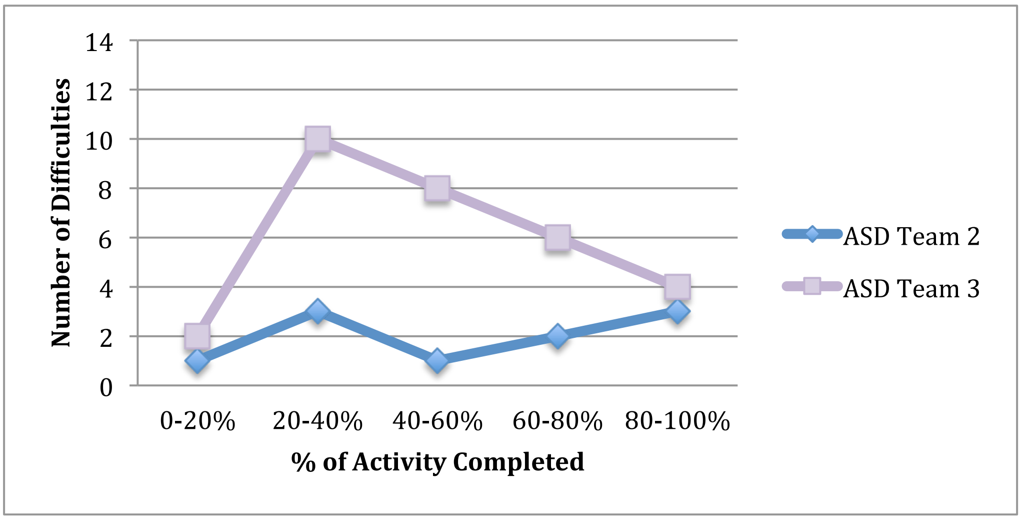
There were indications that children with ASD have the potential to be able to collaborate within this type of computer-based activity, but there were also a number of collaboration difficulties across the two sessions, which will be explored in more detail in the following section.

8.4.2 Study Three Collaboration Difficulties

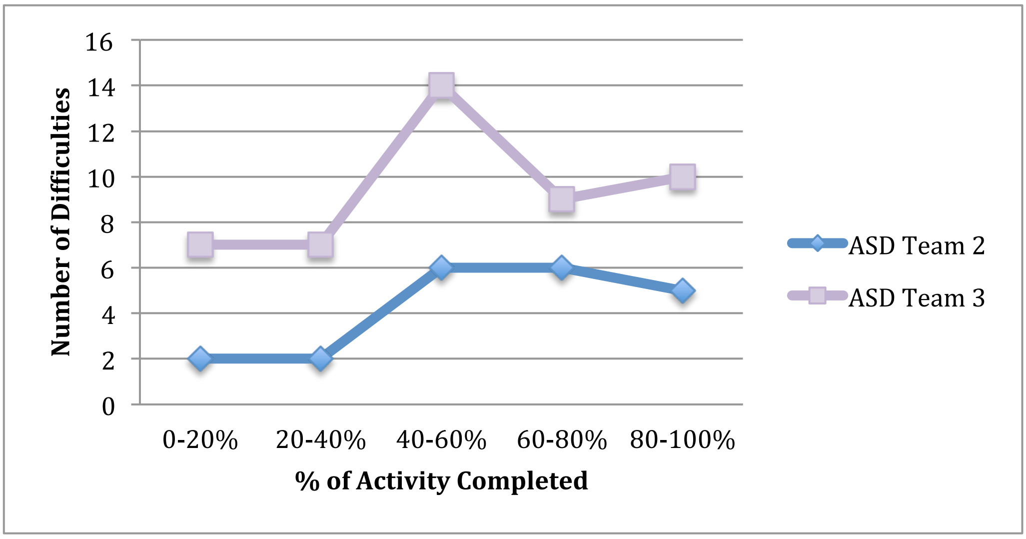
This section addresses the following sub-research question: **RQ3b) Do children with ASD experience any specific difficulties when collaborating with other team members, what is the cause of these difficulties and how are they resolved?** The collaborative activities within the build sessions (session four and session five) during Study Three, were then re-examined to identify any collaboration difficulties, which are important to establish specific areas where children with ASD may require additional support. Again any utterance or action from a child participant that had the potential to negatively impact the collaboration within the team was counted as a difficulty (even if this negative impact did not occur or was not observable). Each of these collaboration difficulties was noted down, along with the collaborative mechanism it violated, where within the activity this difficulty occurred and how it was resolved (if at all). There were *no difficulties* observed within either of the TD teams and therefore the graphs and table below do not include any data relating to the TD teams.

8.4.2.1 Frequency of Collaboration Difficulties

The frequency of the difficulties within the ASD teams is shown in Graphs 8.6 and 8.7, providing the number observed during each period across the two 60-minute design sessions. The children had much more freedom to define the specific tasks they undertook as part of the game development activity and therefore again it is important to take into account that the teams may not have been working on the same task during the same period within the activity.



Graph 8.6 – Frequency of Collaboration Difficulties during Session 4



Graph 8.7 – Frequency of Difficulties in Collaboration during Session 5

The above graphs show that there were more collaboration difficulties within ASD team 3 than within ASD team 2. This could potentially be due to the previous experience ASD team 2 had working together and also having one less child within the team made it more straightforward to make compromises when there was a difference of opinion. However, it is hard to be definitive about this as the children's individual personalities and motivation within the activity may also have an impact. There were a greater number of collaboration difficulties within both teams during session five, which could be explained by the fact both teams attempted to build the more difficult elements of their game during this session. Their frustration with not knowing how to implement certain game elements may have put a greater demand on the level of their collaboration skills to solve these problems as a team. This indicates that different levels of support may be required for activities of different complexity as the effort the children are putting into collaboration (which due to typical ASD deficits would be predicted to more than TD children) may be redirected to the actual task itself when the complexity of the task increases.

8.4.2.2 Types of Collaboration Difficulties

These collaboration difficulties were then examined in closer detail and it was established that they fell into four of the collaborative mechanism categories, which included: difficulty with *negotiation* (disagreements), difficulty with *maintaining awareness* (disengagement), difficulty with *coordination*, and a lack of *encouragement* (unconstructive criticism).

	Reason for Difficulty	ASD Team 2	ASD Team 3
Session 4	Disagreements	**0**	**6**
	Disengagement	**3**	**8**
	Difficulty with Coordination	**7**	**14**
	Unconstructive Criticism	**0**	**6**
Session 5	Disagreements	**6**	**11**
	Disengagement	**8**	**16**
	Difficulty with Coordination	**7**	**24**
	Unconstructive Criticism	**1**	**2**

Table 8.7 – Reasons for Collaboration Difficulties

Table 8.7 clearly highlights that the majority of the collaboration difficulties were related to *difficulties with coordination*, which was specifically related to the coordination of access to the input devices. This was more frequent within ASD team 3 where the two input devices had to be shared between three children meaning that one child was always left without an assigned 'role'. Within both ASD teams there was evidence of *disengagement* when a child was not in control of a device. The children in ASD team 2 had more equal access to the devices, with M3 only becoming disengaged towards the end of the sessions, initiating social conversations with the adults whilst M4 was in control. M4 only displayed instances of disengagement, i.e. looking around the room or fiddling with things, during session five when they had moved onto more advanced functionality that he did not understand. This difference in technical ability was also observed within ASD team 3 during the same session, when M11 would use his advanced knowledge to keep control of the mouse saying he was the only one who understood what to do. For example:

> *M12: "Why can't we come up with some input"*
> *M11: "Because I'm just doing easy questions. Do you have any questions?" [impatiently]*
> *M12: "No not necessarily"*
> *M11: "M13 do you have any questions?"*

M13: "No"
M11: "No ok what is the co-sine of 167"

This indicates the likelihood of collaboration difficulties may be increased if there is a significant difference in the abilities/knowledge of the team members. This may be something that is important to establish at the start of the design process either to enable the adults to provide additional support to the children of lower abilities/knowledge or to match the child team members more closely on their abilities/knowledge during the formation of the teams.

The number of *disagreements* within ASD team 2 was relatively low, but there were occasionally issues during session five. For instance when M4 repeatedly attempted to make an input using the keyboard, which M3 did not agree with, he *physically blocked* M4 from accessing the keyboard when he would not listen to his verbal objections. The children within ASD team 3 more frequently disagreed with each other. These disagreements would often remain unresolved or the child in control of the mouse would simply ignore the objections of the other children and proceed with his own idea:

M12: "No...I hate that"
M13: "No no I'm doing it in my choice so nah nah nah"

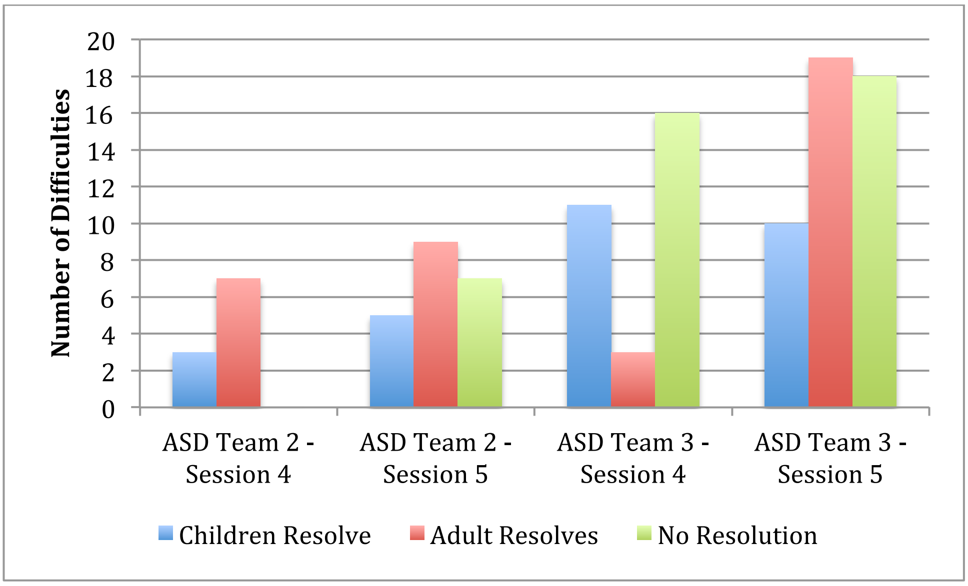
This highlights the difficulty the children within this team had compromising on their own ideas and considering the ideas of others. This was also observed in the problems the children in this team had when giving feedback about other team members' ideas, which on occasions would not be given in a constructive way, for example:

M12: "That's pretty rubbish"
M13: "Why is it pretty rubbish?"
M12: "Because you did it"
M13 "That's not constructive criticism"

This indicates a need for the adults to provide additional guidance to the children in this area, by providing strategies to enable the children to compromise or providing examples of appropriate constructive criticism.

8.4.2.3 Resolution of Collaboration Difficulties

The collaboration difficulties discussed above again resulted in three different outcomes, either the children were able to resolve the difficulty themselves, one of the adults intervened to provide a solution to the difficulty or the difficulty was simply ignored by the children and the team moved on within resolving the issue. Graph 8.8 shows the frequency with which each outcome occurred within the two teams during each session.



Graph 8.8 – Outcome of Collaboration Difficulties

Within ASD team 2 there were instances of adult intervention, particularly when one child had to be told to allow the other child a turn in control of the mouse. Although the children would provide verbal input into the game development when they were not in control of the mouse, they would also sometimes become disengaged often when the other child took a longer turn. There were some instances of the children resolving the collaboration difficulty themselves for example by compromising on their ideas:

> *M3: "I can do the helicopter right now if you want..shall we get rid of this helicopter"*
> *M4: "How about shrink it small"*
> *M4: "Yeah shrink it..yeah make it like that..that's good enough.."*
> *M3: "It looks like it's exploding now..I don't mind this just make it smaller."*

Similarly within ASD team 3 an adult was required to intervene to ensure all of the children had a chance to control one of the devices. However, there were also occasions where they struggled with this, when the child in control of the keyboard would attempt to interfere with what the child using the mouse was doing. This caused disruption to the task and frustration within the team and although the child would apologise, this did not prevent them from doing the same thing later in the session. Adult intervention was also required to keep the children engaged and on task, particularly later in session five when the task became more difficult when they were implementing more complex functionality. The children within ASD team 3 did demonstrate the ability to resolve some of the collaboration difficulties themselves, and showed they were able to compromise on their ideas, for example:

> *M11: "You haven't got that arm yet by the way you can use both I guess..you don't have to get both legs at a time yet..no that looks terrible get rid of the.."*
> *M12: "You can have it in 2 parts like this.."*
> *M11: "Alright bit wasteful..but alright.."*

There were occasions within both teams when the collaboration difficulty was not resolved at all, for instance when a child disagreed with an idea then other children would simply ignore them or they would have a discussion about an issue, but not come to an agreement and instead move onto a different element of the task. Although sometimes the children would simply accept this outcome, on other occasions it would negatively impact the team in other ways. Within both teams ignoring difficulties would sometimes result in the child that was ignored or disagreed with becoming disengaged from the task. This happened more frequently within ASD team 3, increasing the levels of frustration within the team, as the child sometimes resulted to antagonizing the others in order to seek attention. This indicates that it may be beneficial for an adult to intervene in all unresolved collaboration difficulties to prevent them from negatively impacting the team later in the session.

Overall, similar to the previous study, within the collaborative activities in Study Three it was clear adult intervention was still required to manage turn-taking, maintain engagement/awareness and help resolve conflicts within both the ASD teams as they struggled to use appropriate collaborative behaviours at certain points within the activities. One of the key issues was maintaining these collaborative behaviours throughout each session, particularly when they were not in direct control of the computer or the task became more difficult. Some of the children with ASD struggled to manage their frustration with both solving specific issues and coordinating the implementation of the solutions with other team members who may have a less advanced understanding of the task/solution. Therefore this suggests that children with ASD may have the potential to be able to collaborate within this type of computer-based activity, but it is important that an adult is on hand to help overcome any difficulties they are unable to manage themselves.

8.4.3 Study Three Collaboration Implications for IDEAS Method

The findings from the analysis of the collaborative activities within Study Three have a number of further implications for the IDEAS method, which include:

- There was no evidence within the ASD teams of the children's ability to use the socially-distributed productions that were evident within the TD teams. Although it is possible that these were not needed for successful collaboration, there is also an indication of a potential difficulty in this area. Therefore the adults may need to provide additional support to verify the construction of new pieces of shared knowledge to ensure that all team members understand this knowledge in the same way.
- There was further evidence of collaboration difficulties occurring within the ASD teams in relation to the more complex elements of the activity, which again indicates a need for additional adult support to enable progression during these elements of the activity.
- There were more collaboration difficulties when it became apparent that there was a significant difference in the knowledge/abilities of the children within the ASD teams. This suggests a need for the knowledge/ability level of the children to be established prior to commencing the sessions to enable adults to provide additional support to the lower ability children or to form the teams of children of more similar abilities.
- There was evidence of some children with ASD experiencing particular difficulties with compromising on their ideas. This implies a need for the adults to guide the children in making compromises and also discouraging the use of unconstructive criticism.
- It was observed that allowing some of the collaboration difficulties to remain unresolved may have had a potentially negative impact on the ASD team's collaboration and therefore the adults should intervene to ensure all collaboration difficulties are properly resolved before progressing further in the activity.

8.5 Summary of Collaboration Findings from Studies Two and Three

This chapter has discussed the collaboration successes and difficulties within a number of collaborative activities during both Studies Two and Three. Both studies involved collaborative activities, but there was a more explicit need to collaborate during the design activities within Study Three as the team needed to work together to build their game on a single computer. In contrast the collaborative activities examined within Study Two were not central to the game design activity and therefore more loosely coupled. The key findings from this chapter are summarised below, along with the specific limitations of this analysis and overall implications for the IDEAS method.

8.5.1 Relevance to Research Questions

RQ3a) Do children with ASD demonstrate any appropriate collaborative behaviours and how does this impact on the success of the design team?

The findings from this sub-research question have been considered in relation to the typical ASD characteristics impacting the successful collaboration of children with ASD, initially presented in Table 8.1. It is predicted that children with ASD would experience *difficulties with joint attention and maintaining engagement* during collaborative activities. However, there was evidence that the children were able to use deictic gestures and narrations to help maintain the team's awareness of their intentions. There was also evidence of the children maintaining joint attention through offering assistance to another child and adapting their actions based on those of another child through behaviours such as turn-taking. It is also predicted that children with ASD would experience *difficulties with egocentricity and social problem solving* during collaborative activities. There was some evidence of negotiation between the children when they had different ideas and also that when collaboration difficulties did occur that had the ability to resolve these difficulties themselves on some occasions. These abilities enabled the ASD teams to make some progress towards the successful completion of the collaborative activity, however adult intervention was required throughout to ensure that this good collaborative behaviour was maintained and collaboration difficulties were overcome.

RQ3b) Do children with ASD experience any specific difficulties when collaborating with other team members, what is the cause of these difficulties and how are they resolved?

Although there were some collaboration successes it was clear that the children with ASD experienced many more collaboration difficulties that the TD children. These specifically included difficulties with negotiation, maintaining awareness, coordination and providing appropriate encouragement/constructive criticism. There were a number of identified reasons for these difficulties, which included elements of the design task being more tightly coupled and complex as well as significant differences in the levels of abilities and knowledge between team members. These difficulties have resulting implications for the structure and supportive elements of the IDEAS method in order to best enable the successful collaboration of children with ASD, which include providing:

- Highly structured and supported initial collaborative activities, which incorporate the definition of explicit roles, agreement of rules to help guide the collaboration between team members and direct adult enforcement of these roles/rules. This results from the finding that children with ASD demonstrated a more limited number of different collaborative behaviours during early sessions and also required greater adult intervention to resolve collaboration difficulties.
- Adult guidance and enforcement of turn-taking during tightly-coupled tasks, which results from the finding that children with ASD demonstrated more

collaborative difficulties during the more tightly-coupled elements of the activity.

- Potential strategies/solutions for compromising on ideas and overcoming complex problems as well as encouragement to stay on task to prevent disengagement. This results from the finding that children with ASD exhibit more collaboration difficulties and are more likely to disengage during the more complex elements of an activity.
- Visual support for constructing new pieces of shared knowledge for instance by providing multiple options for children to visually document and share new design ideas either on paper or via the computer. This results from the finding that children with ASD are less likely to use collaborative mechanisms such as socially-distributed productions to help support the construction and verification of shared knowledge.
- Pre-screening of children to determine their levels of ability and knowledge in relation to the design task, to allow the adults to build in additional support for lower ability children or to match team members more closely on their levels of ability/knowledge. This results from the finding that children with ASD can become frustrated with others if they do not have the same understanding of the design task and can also become disengaged if they are struggling to understand what other team members are doing.
- Adult interventions for all collaboration difficulties that remain unresolved to ensure these do not result in breakdowns later in the session. This results from the finding that children with ASD sometimes continue with an activity without resolving all collaboration difficulties and these difficulties have the potential to negatively impact on the collaboration within the team.

These implications indicate a need for an additional role incorporated into the adult role definitions defined in the previous chapter, to enable the adults to provide explicit support for collaboration as well as resolving collaboration difficulties. The potential need for greater levels of adult support with collaboration has implications for the balance of power within the IDEAS method. Although the children have been more empowered with regard to their involvement and contribution to the design task, it is important that the adults still have the power to manage behaviour during the task to ensure the children are able to collaborate and progress successfully. This balance of power may also change depending on the complexity of the task, when children with ASD may have an increased need for adult support for collaboration when they are required to expend extra effort undertaking more complex tasks. The provision of this support may also become difficult if the design task is not directed towards achieving clear goals. Therefore it would be predicted that children with ASD may have more success collaborating within structured design environments that require the generation and development of ideas based on design iterations rather than "blue-sky thinking".

8.5.2 Summary and Limitations of Collaboration Findings

These findings indicate that children with ASD have the potential ability to participate within collaborative design activities and successfully complete the activity as a team. However, adult intervention may be required to maintain appropriate collaborative behaviours. The findings showed that the children in the ASD teams experienced particular difficulties with collaboration during more complex and tightly-coupled tasks as well as when there were clear differences in the ability and knowledge of the different team members in relation to the design task. This had the potential to cause problems with turn-taking, compromising, and engagement as well as the resolution of particular issues, requiring adult intervention to ensure it did not become a barrier to completing the overall design task.

This chapter has discussed several interesting findings in relation to the collaboration of children with ASD, however it is important to highlight the difficulty in generalising these findings across a wider ASD population due to the relatively low numbers of children involved in the studies. Certain issues have also been highlighted as problems for some TD children indicating that children's success within collaborative activities is not solely impacted by an ASD diagnosis. It could also be due to individual characteristics, the mix of children, the children's current mood, their familiarity with the adults within the team and the approach the adults choose to take when dealing with any collaboration difficulties. Furthermore, it is also difficult to determine which collaborative behaviours are actually necessary to successfully complete different elements of collaborative activities, which makes it challenging to conclude at which points the children with ASD were less successful than the TD children. Finally establishing the collaborative intentions of the children by retrospective analysis of videos is challenging and it is difficult to interpret these intentions based on solely on the observable utterances and actions. Therefore any conclusions resulting from these findings should be regarded with caution and are intended to provide an initial indication of the possibility of involving an ASD population within this type of collaborative design environment.

The final chapter in this thesis will now incorporate these findings and implications into a discussion that provides an overall conclusion to this research.

Chapter 9 Conclusion

9.1 Thesis Summary

The goal of this thesis was to explore ways to increase the involvement of children with ASD within the technology design process by employing a PD approach. This research has been directed by the following high-level research question: **How can the design contributions, level of participation and collaboration of children with ASD be best supported to enable their successful involvement within the technology design process?**

The specific focus of this work was on the involvement of children with HFA or AS within the design of educational games. Firstly a literature review was conducted within Chapter Two to investigate current theories of autism, approaches to educational intervention as well as exploring the design of children's technology and the involvement of children within the technology design process. It was established that technology offers great potential as an intervention approach within the education of children with ASD, but there are few guidelines on how best to design this technology and involve the target user group within the design process. Researchers had begun to involve children with ASD in the technology design process, but there were no published comprehensive design methods for specifically involving children with ASD, as there were for TD children, that could be easily replicated. Additionally few researchers had considered the collaboration of children with ASD within a design team. These findings resulted in the generation of three specific research questions centred on the design contributions, participation and collaboration of children with ASD within the technology design process and guided the studies undertaken as part of the work presented in this thesis.

The first research question was: **Can children with ASD successfully generate and communicate *design ideas* and what implications do these ideas have in terms of designing educational technology for children with ASD?** This was initially explored in Chapter Four through Study One, which focused on the children's ability to undertake typical design activities on an individual basis. The children were shown some example maths games, asked to generate their own ideas for a maths game and then to choose their favourite idea to draw out the design of the interface for. The findings from this study revealed that the children with ASD were able to undertake these typical design activities, but that some children required additional support in order to do so.

Chapter Five built upon these findings through Study Two, which initially explored the children's ability to undertake these activities within a collaborative design environment. The findings from this study indicated that children with ASD were able to generate appropriate ideas within this type of environment, but emphasized a need for different modes of idea expression to be available and for the adults to take a flexible supportive role within the process.

Chapter Six described Study Three, which additionally involved the children in the build of the prototype technology again within a collaborative design environment and where the children were provided with more activity-based support during idea generation. This additional support enabled them to generate and communicate their design ideas with less adult support.

Separate evaluation sessions were described within each of these chapters, which involved non-participant children (from the participant children's wider peer group) evaluating the design outputs from each of the studies. The specific design outputs along with the results of these evaluations have highlighted a number of implications for the design of educational technology for an ASD population in terms of the visual design, feedback and guidance as well as motivation and engagement aspects. These implications are discussed in more detail in the following section.

The findings related to **RQ1** were also considered in terms of the specific theories of autism and the resulting implications are summarised below:

- *Seeing the 'bigger picture'* – the incorporation of unconnected ideas by the participant children with ASD within their maths game during Study Three and the tendency of the non-participant children with ASD to assess the games based on their specific features during the evaluation activities within all studies indicated issues with considering the game as a whole rather than individual elements. This follows the **WCC theory** (Happé and Frith, 2006), which predicts a tendency to focus on the finer details rather than seeing the 'bigger picture' and also by the **E-S theory** (Baron-Cohen, 2009), which predicts a drive to understand systems (i.e. the game) by focusing on the individual parts. However, within Study One it was observed that the children with ASD generated their game ideas at different levels of abstraction, with some children able to generate high-level game ideas, which does not follow the prediction of these theories. This highlights the difficulty of one theory explaining the behaviours of such a wide spectrum of individuals.
- *Empathising with others* – the lack of awareness and intolerance of some participant children with ASD with regard to the time needed for idea generation by other team members during Study Three, the preference for negative critical feedback to be incorporated within their games during Study Two and the lack of consideration of other children's preferences by the non-participant children with ASD during the evaluation activities across all three studies demonstrated a general difficulty empathising with other children. This follows the **ToM** and **E-S theories** (Baron-Cohen, 2000b, Baron-Cohen, 2009), which predict this deficit in empathy, due to difficulties with understanding what others are thinking.
- *Narrow special interests* – the theming of their game ideas and incorporation of very specific (and often irrelevant) game features by the participant children with ASD suggests the influence of very narrow special interests on the generation of their ideas. This follows the **ED** and **E-S theories** (Ozonoff et al., 1991, Baron-Cohen, 2009), which predict the occurrence of these narrow obsessive interests due to either difficulties in switching attention or above average systemizing skills.

The second research question was: **To what degree can children with ASD participate in the design of technology and taking account of existing theories of ASD, how do *existing design methods* need to be adapted to enable this participation?** Chapter Three initially addressed this research question through the initial analysis of a number of existing PD methods and techniques for TD children to establish their suitability for children with ASD. As a result of this analysis a new PD method called IDEAS was developed incorporating a number of appropriate existing features as well as some further novel features to enable the method to best meet the needs of an ASD population. The initial trial of this method during Study One with individual children, described in Chapter Four, highlighted the demand for a flexible approach to be taken, allowing "on the fly" tailoring of the method to individual children's specific needs and for the adult(s) involved in the process to undertake a number of different roles. It also revealed a need to allow time within the process for the children to build relationships with the adults, to establish clear rules to guide the process and to undertake the sessions in a quiet distraction-free environment. These findings enabled the IDEAS method to be refined for use within a collaborative design environment during both Study Two and Study Three.

Chapter Seven examined the findings from Studies Two and Three in terms of the children's level of participation. As part of this the role of the adult was further explored and a number of different adult roles were defined. It was also found that the use of technology and the link between the design task and the children's special interests helped to increase the children's level of engagement within the sessions. However, increased demands on teamwork skills and concerns about the quality of work due to limited time/technical skills could negatively impact the children's participation. This highlighted a need to ensure expectations are clearly set at the start of the process, the ability levels of the children within the team are matched and sufficient time is allowed to enable the children to produce a design output that they are satisfied with. The benefits of the children's participation were also explored and the teaching staff members from each of the design teams highlighted a number of potential benefits.

Through this research question the issue of power imbalance was also highlighted as it became clear that the adult's role needed to incorporate the power to manage the children's behaviour, but at the same time the children's role was also able to evolve over the sessions empowering them through their contributions to the idea generation, prototype development and decision-making during the design process. This was facilitated by a number of IDEAS-specific features which included empowering the children to define their own session rules, allowing them to set session tasks, providing the opportunity for the children to define their own responsibilities during the tasks and equipping them with the technical skills to implement their design ideas themselves. The decrease in the levels of adult prompting within the ASD teams during Study Two and also a decrease between Study Two to Study Three within the ASD team who participated in both studies as well as the potential benefits of the children's participation indicated the evolution of this empowerment.

The findings related to **RQ2** were also considered in terms of the specific theories of autism and the resulting implications are summarised below:

- *Seeing the 'bigger picture'* – the fact some of the participant children with ASD initially appeared overwhelmed with the design task during Study Two and needed to focus on individual elements of the task (facilitated by the adults) before idea generation could begin indicated a difficulty with understanding the 'bigger picture'. This follows the **WCC theory** (Happé and Frith, 2006), which predicts a detailed-focused preference in children with ASD and also the **E-S theory** (Baron-Cohen, 2009), which predicts a need to understand the system by breaking it down into component parts (something that the children in this case struggled to do without adult support).
- *Empathising with others* – the communication difficulties between team members with lower abilities/understanding and the more able participant children with ASD during Study Three, and resulting frustrations within the teams demonstrated a lack of ability to emphasize with other children. This follows the **ToM** and **E-S theories** (Baron-Cohen, 2000b, Baron-Cohen, 2009),

which predict this deficit in empathy due to difficulties understanding what others are thinking.

The third and last research question was: **What factors need to be considered to enable children with ASD to *collaborate* with others during design sessions?** Chapter Eight explored the collaboration of the child design team members during Studies Two and Three by focusing on specific collaborative activities within the design process. An analysis of the collaborative behaviours the children exhibited during these activities as well as the identification of any difficulties with this collaboration and how these difficulties were resolved revealed a number of areas where children with ASD may require additional support in order to successfully collaborate with other design team members. The findings showed that the children had the ability to successfully employ certain collaborative behaviours during the activities, but there was a need for adult intervention on occasions to resolve collaboration difficulties. This adult intervention was needed particularly to aid social problem solving, to support the contributions of less dominant children and also to maintain awareness towards the latter or more complex parts of the activity when the children could become tired or frustrated.

These findings again highlight the need for the adults to undertake a series of different roles to support the children during the sessions. The findings indicate a potential need to consider the children's level of communication, social and technical skills as well as individual personality characteristics in advance of forming the design teams to provide the best setup for successful collaboration. However, successful collaboration is typically achieved through the participants combining their different knowledge, characteristics and skills. Therefore a balance needs to be achieved in terms of a combination of complementary and overlapping experience and expertise, ensuring the discrepancy between the children is not too pronounced.

These findings were also considered in terms of the specific theories of autism and the resulting implications are summarised below:

- *Empathising with others*: the disagreements, provision of unconstructive criticism and difficulties in compromising observed amongst the children with ASD indicated problems with empathising with other children. This follows the **ToM** and **E-S theories** (Baron-Cohen, 2000b, Baron-Cohen, 2009), which predict this deficit in empathy due to difficulties understanding what others are thinking.

This chapter concludes the thesis by presenting the key findings, contributions and limitations of this research as well as highlighting potential further work.

9.2 Discussion of Findings and Contributions

The key empirical findings within this research have been discussed in the previous chapters. Below the overall findings of this thesis are summarised in terms of the key contributions of the work. The primary contribution of this research, the IDEAS method, is presented first, followed by the secondary contributions.

9.2.1 Contribution 1: A new PD method for children with ASD

A review of the child PD literature undertaken earlier in this thesis revealed several existing PD methods and techniques aimed at TD children that were reported in sufficient detail to allow other researchers and technology designers to apply them in other contexts. However, it was established that there were no existing PD methods or techniques specifically tailored to the particular needs of an ASD population. It was also found that many of the projects aiming to design technology for children with ASD would often use parents or teachers as proxies for the children or involve the children themselves at later points in the technology design process. Although there are examples from a small number of projects where attempts have been made to involve children with ASD more fully within the design process, none of this work has systematically examined (over an extended time period) the level of participation children with ASD are able to undertake, the type of design contribution they are able to make or their ability to make these contributions within a collaborative design environment. This thesis has explored each of these areas and the findings from this work have informed the development of a new PD method, IDEAS.

The IDEAS method is the key contribution of this work. The method is specifically tailored to the needs of children with ASD, and intended to be used to involve this population within a design team over an extended period of time. IDEAS can be used within a school setting, both in facilitating the design of the technology as well as incorporating an option to involve children with ASD in the build of technology prototypes.

9.2.1.1 Overview of the IDEAS method

Within the IDEAS method it is recommended that adults from a range of backgrounds should be involved within the design team, including researchers with both technical skills and knowledge of ASD as well as at least one teaching staff member who is familiar with the child participants. Additionally the ability level of the children in terms of their verbal communication skills, reading/writing skills and technical skills should be assessed prior to involvement within the design team to ensure materials can be tailored to the appropriate level and the ability level can be matched between the children where possible.

The IDEAS method incorporates both structured and supportive elements. The elements of *structure* include the organisation of the design environment as well as the sequence, scheduling and format of the design activities. The elements of *support* include the different forms of adult support, the presentation of the materials used in the design activities as well as matching the content of the activities to the children's interests. The framework of the IDEAS method allows the balance of structure and support provided within each of the design activities to be tailored to the needs and characteristics of the individual children participating in the session. This allows the more able and confident children the creative freedom to develop their ideas themselves, whilst at the same time allowing the less able children to participate in the activities they find challenging.

The IDEAS method is presented diagrammatically in Figure 9.1, with a dashed line separating the elements that are only relevant if the children are additionally being involved within the build of the prototype technology. The elements added prior to Study Two are highlighted in red and the elements added prior to Study Three are highlighted in blue. Additionally the structured elements of the method are filled in white and the supportive elements of the method are filled in colour.

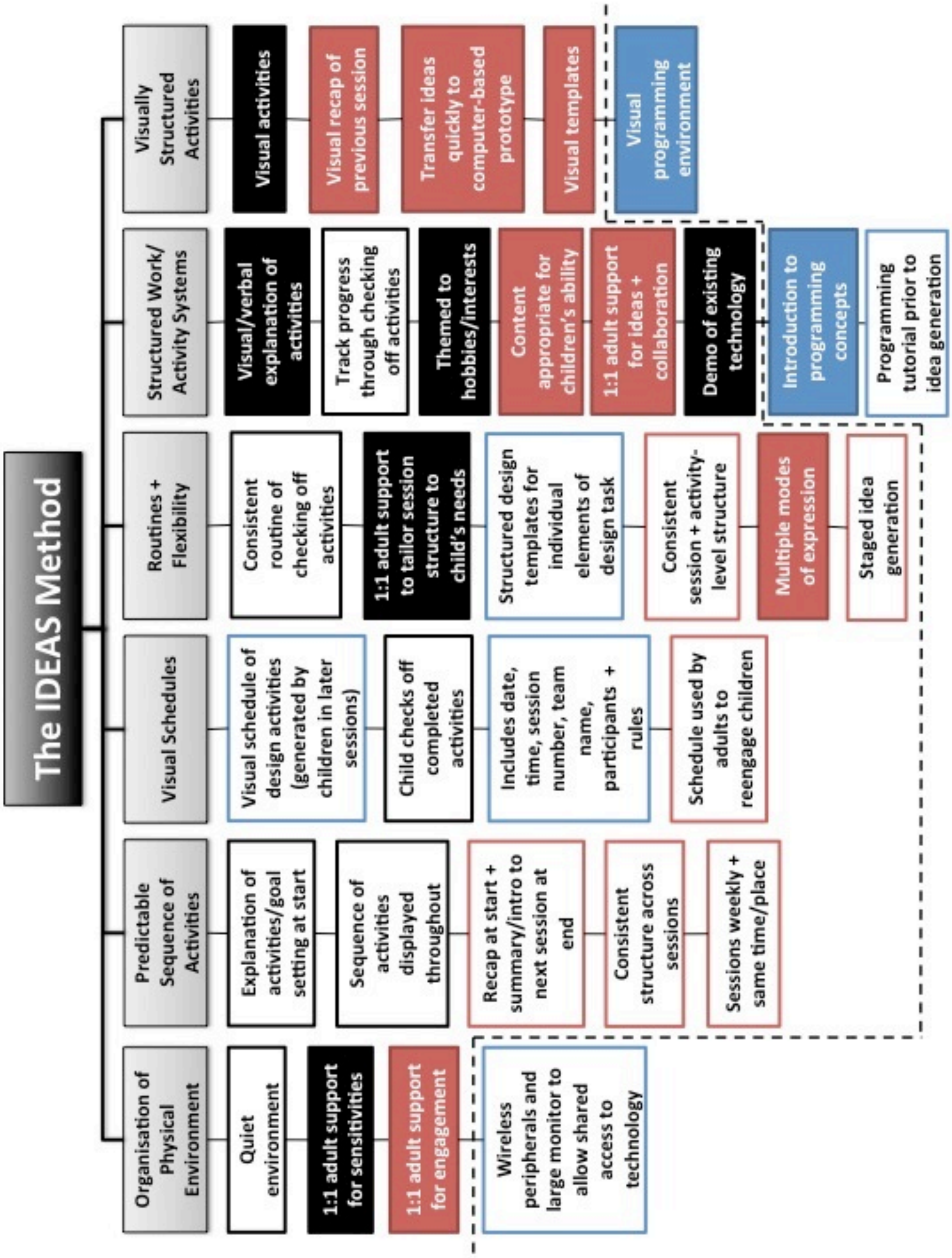


Figure 9.1 – Final version of the IDEAS method (elements of method only applicable to building prototype below dashed line)

9.2.1.2 The IDEAS method in practice

The IDEAS method is intended to be flexible to enable it to be adapted based on the needs and constraints of the specific project it is employed within. Below is an example of how the method could potentially be applied, with aspects that could be modified based on the context or constraints of the specific project highlighted in bold.

Setup

The design team undertake a series of **six** design sessions on a **weekly** basis, with each session lasting approximately **one hour** and being conducted at the children's school in a quiet room separate from their classrooms. A whiteboard-based visual schedule displays the list of activities for the session, date and session number as well as the team name, rules and team portraits. One child per session is assigned (or can volunteer for) the responsibility of checking off the tasks. Each session begins with a visual recap of the previous session, except for session one which begins with a visual overview of what each of the design sessions will involve. The teams are set the task of designing (**and developing**) a **particular technology** for their peers, which is introduced at the start of the first session.

Below is a description of six design sessions, however the **design activities** involved in each session could be combined/reduced or expanded upon depending on the time and resource constraints of the specific project.

Session 1 (Team Building)

Begin with a **basic introductory activity**, such as drawing portraits of other team members, to act as an ice-breaker. Next ask the team to collectively generate and agree upon a team name and set of rules to guide behaviour, which everyone agrees is important and that they are happy to follow during the sessions. Lastly play a **team-building game** that has clear rules to provide an opportunity for participants to practice teamwork skills within a fun and structured context.

Session 2 (Context Setting)

Begin with the **demonstration of existing technology** similar to the technology that the design task for the sessions is focused upon. This can be demonstrated by showing pre-recorded videos of the technology or by asking the participants to interact directly with the technology, depending on the available resources and the likelihood of the participants becoming distracted by using the technology. Follow this with a discussion about the participant's opinions of what is good/bad about the existing technology. A further **discussion about the participant's previous experiences** related to the design task to help provide additional context can also be incorporated. If the participants will be involved in the *prototype development* during the design sessions a **tutorial to introduce the programming tools** that will be used to build the prototype in later sessions can be incorporated during this session.

Session 3 (Idea Generation)

Begin with the **demonstration of the existing technology** to be improved upon or an example of a very basic design idea that the participants can build on, to help inspire initial idea generation. Provide **paper-based templates** for each of the **lower-level elements of the technology** being designed, and be prepared to **provide example ideas** for each of these elements if any participants struggle to begin generating their own ideas. Ask participants to initially spend some time generating their own individual ideas for each technology aspect, and to **write/draw these ideas** on each of the templates. The completed templates should then used to guide a **group discussion**, with each element discussed in turn and participants sharing their own individual ideas. Then ask participants to agree on their chosen idea(s) for each game element, which can be **noted down by one of the adults on a separate template.** Lastly, provide a **paper-based computer interface template** and ask participants to draw out what they would want the technology to look like.

Session 4 (Design Development)

Begin with a recap of the team ideas agreed during the previous session. If solely focusing on the *technology design*, show the participants a **computer-based representation of the current team designs** for each **element of the technology** that is to be considered within the design task (e.g. the primary screens). Then provide the participants with **individual paper-based templates for each technology element** and ask them to generate ideas to improve the design by first **writing/drawing their individual ideas** on the template and then verbally sharing them with the team. Lastly provide **'team' paper-based templates for each technology element** and assign responsibility for this template to one of the participants. Encourage the participants to use the individual templates to guide the decision as to which ideas to take forward, and ask the participant responsible for each technology element to **document the chosen ideas on the template**.

If focusing additionally on the *prototype development* ask the participants to think about the development tasks they need to focus on first and to **agree a list of activities** that should be completed during the session. These should be written on the whiteboard-based visual schedule. **Appropriate resources** should be provided to allow participants to collaborate on the prototype development. Provide participants with their designs produced during the previous session and ask them to collectively begin building the prototype as a group using the agreed list of tasks and paper-based designs.

Session 5 (Design Refinement)

This session can follow a similar structure to the previous session. If solely focusing on the *technology design* then a researcher can develop the **computer-based prototype** outside of the design sessions based on the team designs and demonstrated at the start of the session. Then provide the participants with **paper-based templates** containing visuals of the current prototype, enabling them to follow a similar **process** to the previous session to further refine these designs.

If focusing additionally on the *prototype development* ask the participants to agree a **list of activities** that needs to be undertaken to complete their technology prototype and to write these on the whiteboard-based visual schedule. Then ask participants to finish as much of their **prototype technology** as time allows. At the end of the session ask participants if there is anything they did not have time to finish or incorporate. These **features can be noted down and finished** by a researcher prior to the last session.

Session 6 (Evaluation and Reflection)

This session can be used to provide the participants with an opportunity to evaluate and reflect upon their achievements during the design process. Begin with a **demonstration of the final technology prototype**. **Feedback can be gathered** on this through verbal discussion or paper-based questionnaires. In order to help the participants reflect on their achievements, provide them with **visual representations** of each of the different design activities that they have completed during the sessions and ask them to create a **display of their work**. This could be structured through the use of **paper-templates**. The resulting display can then by used to guide a **presentation** to teachers and/or parents to provide the participants with a chance to 'show off' their achievements. To **thank the participants for taking part** they can be given certificates, a small gift e.g. stationary and/or a copy of the prototype technology.

9.2.2 Contribution 2: Guidelines for supporting children with ASD to generate design ideas

The second contribution of this thesis is the provision of a set of guidelines that can be used to support children with ASD during the idea generation process. These guidelines are based on the findings from all three studies described within this thesis and are summarised below:

1. Provide the children with a starting point that is more than a blank piece of paper such as a basic wireframe structure on which they can build or some example ideas that they can use as a guide.

2. Ensure the design task is not too general, but instead starts at a low-level focusing on specific elements and considers the ‘big picture’ once the children have become more comfortable with the idea generation process.
3. Provide structured paper-based templates on which the children can document their ideas, which guide the children in the documentation process and include visual prompts to inspire the idea generation process. This can reduce the need for verbal prompting from an adult.
4. Allow a number of different methods in which the children can express their ideas including writing, drawing and verbal discussion, enabling them to share their ideas using their preferred method.
5. Provide a way to represent the children’s ideas in a concrete manner for instance when generating interface design ideas through the provision of a paper-based template incorporating the outline of a computer screen, a cardboard mock-up computer in which to insert the paper-based interface design ideas or by quickly transferring the children’s ideas onto the computer and displaying them on the screen.
6. Adults should undertake a flexible role throughout the idea generation process, maintaining an on-going awareness of the progress each child is making and intervening if any difficulties are observed. There may also be a need to provide motivational support, encouraging any children who become disengaged or who are low in confidence. The adults should provide the minimum amount of support each child needs to generate their ideas to allow them the maximum creative freedom within the process.
7. Additional supplementary activities should be prepared in advance of the sessions for use with any children who generate ideas more quickly than others. This will allow the slower children the opportunity to think through their individual ideas at their own pace without distraction from other children within the team.

9.2.2.1 Contribution 3: Definitions of the adults’ roles within the PD process

The third contribution of this thesis is the definition of the roles that an adult can undertake during a PD process that involves children with ASD (see Table 9.1). This set of roles could also be applied to adults participating in a design team that involves TD children. These definitions can help adult participants to understand and prepare for the different types of roles they may need to undertake in advance and highlights the potential requirement to transition between different roles during a single session in accordance with the current support needs of the child participants.

Role	Definition
Facilitator	Adult sets the agenda or the structure for the session, provides additional explanation, facilitates a consensus within the team, clarifies ideas/opinions, coordinates access to resources, offers appropriate technical support or helps to enable progress in accordance with the research plan to facilitate the children's participation within the session.
Motivator	Adult provides praise or encouragement to help motivate the children's engagement within the session.
Caregiver	Adult maintains the children's wellbeing by providing support for any non-task related problems/issues the children have during the sessions.
Participant	Adult contributes an idea or expands upon another participant's idea.
Contribution Initiation	Adult explicitly prompts a child to contribute an idea or opinion.
Behaviour Management	Adult explicitly prompts a child to maintain good behaviour.
Collaboration Guidance	Adult intervenes in any collaboration difficulties which children are unable to resolve themselves through the coordination of turn-taking, prompting the maintenance of engagement/awareness, providing examples of good collaborative behaviour or suggesting solutions to conflicts.

Table 9.1 - Definitions of Adult Roles during the Technology Design Process

9.2.3 Contribution 4: Understanding of the collaboration of children with ASD within a PD context

The fourth contribution of this thesis is a greater understanding of the collaborative abilities of children with ASD within a PD context. The collaborative activities undertaken during Studies Two and Three have established that children with ASD have the potential to work with others and exhibit a number of different collaborative behaviours to successfully complete design activities, with the potential to learn some of these collaborative behaviours through continued involvement within a collaborative environment. These mechanisms include the ability to use *narrations* to help others maintain awareness of what they are doing, *encouraging* others through praising their ideas, demonstrating an ability to *negotiate* on their ideas as well as participating within *social conversation* with both other children and adults within the design team.

There was also evidence of their ability to use both *deictic* and (to a lesser extent) *non-verbal* gestures to focus others attention, *monitor others' actions* and provide input on these actions, display an awareness of the meaning of others' *body language* and recognise when they can *offer assistance* to others. Finally the children were able *to coordinate their actions* with one another as well as *coordinating the available resources* and their *roles* within the team.

Although there were signs of a number of collaborative behaviours there was also evidence of the difficulties children with ASD had with collaboration, which often required adult intervention in order to resolve the collaboration difficulties. It was clear that the children experienced problems with different elements of the collaborative activities, meaning that some level of adult involvement was required throughout. There were also issues with more highly coupled and complex activities such as during the game building activity undertaken during Study Three, which required the children to share resources and collectively agree solutions to game implementation problems. These resources enforced the need for direct cooperation between the children, helping to make the turn-taking more explicit, but resulted in more collaboration difficulties if the children were unable or did not want to share these resources fairly. In these cases adult intervention is required to enforce collaboration, however for children that may still find this type of collaboration too challenging the activity could be adapted to become more loosely coupled by allowing the children to undertake individual activities, which each contribute towards a collective team goal.

There has been little exploration of the collaborative ability of children with ASD within the PD literature, with some researchers believing difficulties with communication and social skills that directly impact their collaborative ability can become a barrier to involving them more fully within the design process (Kientz et al., 2007, van Rijn and Stappers, 2008b, Francis et al., 2009, Madsen et al., 2009). However, this work raises the possibility that with appropriate support some children with ASD may be able to undertake a more involved role within a design team than many researchers currently consider them able to. Involvement within this type of process may also offer this population the opportunity to develop their collaboration skills, which could also have a positive impact in other areas.

It is important to highlight here that the children involved in this work were high functioning and were not impaired in their spoken language. Therefore these collaboration findings could not be applied to a low-functioning ASD population due to the reliance within this context on verbal communication skills.

9.2.4 Contribution 5: Guidelines for supporting collaboration within a design team

The fifth contribution of this thesis is a set of guidelines for adults to best support the collaboration of children with ASD within a design team. These guidelines are based on the findings from Study Two and Three and include:

1. Establish an understanding through discussions with teachers of the children's current communication skills, social skills and any other skills relevant to the design task. Match the ability levels of the child participants within the team wherever possible, also taking into account individual personality characteristics and the existing relationships between children.
2. During the establishment of the team rules the adults should encourage the children to consider and agree on specific rules for guiding the collaboration within the sessions.
3. Adults should provide role-based guidance and motivate the children to undertake their individual roles and responsibilities within the team.
4. Adults may need to moderate turn-taking and transitions between roles. Where difficulties with turn-taking persist during highly coupled activities, the adults may wish to adapt the activity to allow the children to each contribute individually towards a collective team goal.
5. Adults may need to prompt individual children to ensure all team members contribute towards the design activity.
6. Adults need to monitor the children's engagement within the activities and provide opportunities for children to re-engage if they become distracted or disinterested, such as initiating a transition in roles or asking the child to make a specific contribution. This will help to ensure the children maintain awareness of the activity.
7. Adults need to anticipate inappropriate collaborative behaviour resulting in collaboration difficulties or breakdowns and take appropriate action to mitigate these breakdowns.
8. Where collaboration difficulties occur adults need to intervene if the children are unable to resolve the difficulty themselves and adopt collaborative repair mechanisms for specific collaborative problems.

9. Adults may need to provide additional support during problem solving, providing encouragement, motivating children to persevere with the problem and offering potential solutions where appropriate.
10. Adults may need to provide additional support to help children negotiate their ideas, mediating discussions, suggesting possible compromises and discouraging egocentric behaviours.
11. All collaborative activities should incorporate multiple options for the children to contribute. It should be possible for the activity to be adapted by the adults during the session if the children are finding tightly coupled collaborative tasks too difficult by providing the option to individually contribute towards the collective goal.

The likelihood of successful collaboration is dependant on a number of factors, some of which are outside of the control of the researchers such as the child's current mood and events that have happened earlier in the day. Following these guidelines may increase the potential of the children with ASD being able to successfully participate within collaborative activities, but does not guarantee it.

9.2.5 Contribution 6: Potential benefits of PD for children with ASD

The sixth contribution of this thesis is an understanding of the potential benefits that children with ASD can gain from their involvement within the PD process. In addition to evaluating the potential benefits from the outcome of the PD process this work has also considered the potential benefits to the participants of the process. This has been highlighted within the literature as an important consideration in relation to the empowerment of children within the PD process (Hussain, 2010). These potential benefits to the children have been gathered from the teaching staff members involved in design teams during both Studies Two and Three and include:

- Improved teamwork/social skills
- Learning about turn-taking
- Improved ability to compromise
- Learning to share
- Improved imagination/creativity skills
- Improved technical skills
- Improved relationship with adults
- Increased confidence
- Sense of enjoyment

It cannot be said definitively that if children with ASD are involved in the PD process they will benefit in all or even a subset of these ways. There is the potential that the children could benefit in some way, but this is dependant on the individual child involved, their current ability/skills levels, their severity of ASD and individual personality characteristics such as their initial willingness to participate and interest in the design task.

9.2.6 Contribution 7: Educational technology design principles for an ASD population

The final contribution of this thesis is a set of design principles that can be used as a guide by designers of educational technology aimed at children with ASD and who are unable to take a full PD approach to the design of this technology due to time or resource constraints. These principles provide a guide to ensuring the technology is both appropriate and appealing for children from the ASD population. This is by no means a comprehensive set of principles, but is based on the findings from the studies described within this thesis and could potentially be built on further by other researchers working in this area. The design principles introduced within Chapter Two have been used as a framework, but those principles that are unrelated to any of the findings within this thesis have been excluded. The remaining principles are a summarised list based on the educational design principles discussed and refined through the work presented in Chapters Four, Five and Six (see sections 4.3.1, 5.4.3 and 6.4.3).

Visual Design:

1.1. The incorporation of both animation and sound is important to make the technology appealing to children with ASD. Both the animations and sounds should be realistic where appropriate. Additionally the potential auditory sensitivities of children with ASD should be considered and there should always be options for the user to control the volume and the exclusion of specific sounds.

1.2. Children with ASD can express a preference for bright colours (like many TD children), but it is important to strike the correct balance of colours, offering the option to change background colours to match individual children's preferences and not to rely on the ability to recognise colours to differentiate different aspects of the interface.

1.3. The specific graphical elements incorporated into the interface are particularly important in terms of the overall appeal of the technology for children with ASD. They should be realistic and it should be ensured the interface is uncluttered. Incorporating an overall theme can help to increase the appeal of the technology, but this would need to be adapted to the specific preferences of the user, as children with ASD can have very individual preferences and therefore it can be difficult for any theme to have a broad appeal within this population.

1.4. Text should be kept simple, as some children with ASD can have additional difficulties with reading and can be discouraged from using technology they find confusing or difficult. There should also be an option for text to be read aloud and for it to be accompanied by graphical representations where possible to provide additional support for poor or impatient readers.

1.5. Content should be designed to appeal to the particular interests of the children. However, it is important to remain aware of violence-related content that children may find very appealing, but is inappropriate for use with their age group and within an educational context.

Feedback and Guidance:

2.1. Feedback can be provided through a range of mechanisms including simple text, animations, sounds and penalties within the game. Although feedback should be made non-critical to avoid concerns about failure, it needs to be given directly and made explicit to ensure the child knows that they have got an answer correct or incorrect.

Motivation and Engagement:

3.1. The incorporation of fun features such as bonus content, mini games or random features can help to increase the engagement of children with ASD with the educational technology.

3.2. The use of reward mechanisms such as plot animations and pictures, achievement acknowledgement systems, score systems, gaining resources and unlocking mechanisms can be motivating for children with ASD. The incorporation of the children's special interests within these rewards can increase motivation further.

3.3. The ability to personalise technology is extremely important for children with ASD due to the wide range of individual differences within this population and the very specific preferences these children have. Options to customise the theme, specific graphics, colours and sounds would help to increase the appropriateness and appeal of the technology.

9.3 Limitations and Future Directions

The scope of this thesis was defined within the Chapter One and the implications of scoping the research in this way along with a number of further methodological implications are described within this section. These limitations indicate potential areas the work reported within this thesis could be taken further in the future and the directions this further work could follow are also discussed.

9.3.1 Focus on Children with HFA/AS

This work focused solely on children with HFA or AS, which excluded a large part of the ASD population. This decision was made to ensure participants would be able to verbally communicate their ideas, opinions and difficulties, which enabled the success of the method to be more concretely established without solely relying on adult interpretation of the children's behaviours. Due to the vast gulf in ability levels between children with HFA/AS and those at the lower functioning end of the spectrum many of the findings from this work would not necessarily be applicable to low-functioning ASD population. However, the PD method and guidelines developed during this study could provide a starting point for exploring the greater involvement of children from the wider ASD population within the technology design process.

Features such as the provision of one-to-one adult support and concrete examples of the technology could additionally be used with a wider population. The structured approach to the design process underpinned by TEACCH could still be followed. However, there may be a requirement for this structure to be increased in terms of the provision of template support containing example ideas, where the children may be supported to express preferences between ideas rather than being asked to generate their own ideas. The visual nature of the activities would appeal to this population and instructions could be given solely through visual means, based on similar intervention strategies such as the Picture Exchange Communication System (PECS) (Vicker, 2002).

9.3.2 Choice of Design Task

The task of designing an educational game, focused on by all three studies within this thesis, was purposefully chosen to appeal to the child participants. It was clear from teacher reports and the children's conversation that playing computer games formed a major part of many of their daily lives. As few researchers had attempted to involve children with ASD as fully as they have been involved within this work it was important that a dislike or disinterest in the design task did not become a barrier to their participation. It was essential to firstly establish the ability children with ASD have firstly to undertake certain design activities, and secondly to participate within a collaborative design environment.

Children with ASD can be uncooperative in activities that do not interest them (Attwood, 1998), therefore if the design task did not interest them it would not be known if they could not or *would* not participate in certain activities. The studies reported within this thesis would most likely not have been as successful had they focused on a less appealing task. However, this approach has enabled a new PD method to be developed that provides tailored support to children with ASD and this could in future be applied alongside a variety of different design tasks. One key feature of the IDEAS method is the incorporation of the children's special interests either within the design tasks themselves, within the discussions during the sessions or as a reward for participating. This could help to provide the motivation for them to participate if the design task itself is less appealing to them.

One of the contributions of this thesis is a set of principles for the design of educational technology. However, it is acknowledged that this thesis had focused on a small subset of children's educational technology, namely educational games that can be played on desktop/laptop computers. Therefore although these principles may apply to a wider set of educational technologies there will be additional principles needed for these different forms. It is hoped that the design principles presented in this thesis will provide a starting point for designers of technology for children with ASD to build upon, in order to cover a variety of different forms of technology.

9.3.3 Participant Selection, Matching and Generalisation

One of the main limitations of this work is the relatively low numbers of children participating within the design sessions in relation to the wider population of children who are diagnosed with ASD. There were a number of restricting factors within this research, which included the time consuming nature of these studies in addition to a reliance on the following:

- The participation of other researchers.
- Resources, teacher time, commitment and general involvement of the schools.
- Access to children who fulfilled the age and ability criteria.

These factors meant that a limited number of individual children and design teams participated in the studies within a relatively short timeframe. These limited numbers mean that it is difficult to generalise these findings to a wider ASD population due to the highly individual nature of children on the autism spectrum. There are a number of further factors, which could impact the results of the design sessions including:

- The individual interests of the children, how these interests link to the design task and their overall motivation to participate.
- The mix of children chosen to participate within a single design team, their individual personality characteristics and their existing relationships with the other children and adults on the design team. For instance within the design team studies the children with ASD were all familiar with one another prior to the study, but not all of the TD children knew each other. A prior familiarity could have both beneficial and negative effects on the team. If the children have existing friendships this could help to increase the enjoyment and productivity within the team. On the other hand it is also possible that the children could dislike one another or have had a disagreement in a previous lesson that could negatively impact the current design session. The differing levels of familiarity of the children within the TD teams could also have an impact. Where none of the children knew each other prior to the study they may require additional time to build up these relationships to ensure the children feel comfortable enough to share and critique one another's ideas. Where only some of the children knew each other, this could make it harder for the other child/children to feel part of the team. Again additional time or alternative team building activities may be required here to ensure everyone feels they can undertake an equal role within the team. To mitigate these concerns it would be useful to engage adults who are familiar with the children within the participant selection process.
- Design team members missing sessions due to illness or other school activities.
- Children with ASD having a 'bad day' or events that happened earlier in the day negatively affecting their engagement within the session.

- The profile and culture of the school where the sessions take place. The schools that participated within this research were all attended by pupils of mixed faith, ability and socio-economic status. However, it is not known if this mix was reflected within the design teams and how this impacted the study findings. Additionally school procedures, such as disciplinary processes, may impact the behaviour of the children within the sessions, their view of the adult's role and authority, and also their willingness to question the adult team member's ideas and suggestions.
- The teachers involved in the sessions, their familiarity with the children and the design task, as well as their general interest in and willingness to support the research agenda. For instance within the design team studies there was difference in the teaching staff member's familiarity with the children, between the ASD and TD teams. The teaching staff member within each of the ASD teams was able to provide support that was more personalised to individual children due their familiarity with the child participants. Although there was less of a need for support within the TD teams, an increased familiarity may have benefited those children who found participating within this type of collaborative design environment more challenging. Additionally the role of the teaching staff member within the school could have an impact, for instance in may be more difficult for the children within the teams that included a maths teacher to undertake a role equal to the adults than the teams that included a learning mentor or a teaching assistant, who have less of an authoritative role within the school.

Therefore further work would need to be undertaken to confirm the findings reported in this thesis within different contexts, over an extended time period and to establish the generalizability of the findings to the wider child ASD population.

There were also limitations with the matching of the ASD and TD groups. The children were matched as closely as possible on age, gender and verbal IQ, but it was difficult to assess other relevant abilities such as technical skills prior to the sessions due to the time consuming nature of these assessments and a need to minimise the disruption of the research to both the children and schools. The verbal IQ assessment also did not always provide a reliable measure of the children's verbal ability, as some children were disinterested by the assessment and therefore the results did not always fully reflect their verbal ability within activities, which were of interest to them.

It was also unknown if the TD children had any additional special needs which may have impacted their ability within the sessions. Due to the sensitive nature of some of this information and the fact this was not a direct research interest, this information was not sought from the schools. However, it could be inferred that the children were not diagnosed with any special needs that meant they were unable to attend mainstream school, as the children with ASD who participated in the studies did.

9.3.4 Research Methods

The field studies undertaken during the course of this research generated a very rich data set, which has resulted in some interesting findings in relation to the involvement of children with ASD within the technology design process. However, due to the time-consuming nature of these studies it was not possible to trial the IDEAS method with a large number of design teams, making it problematic to generalise the findings to a wider population. It was also not possible to undertake the sessions over the extended time period typical of PD studies, resulting in limited data regarding the longer-term impact of involvement in the technology design process on the participant children.

Taking a qualitative approach to the analysis of the data set proved to be challenging, due to the sheer amount and richness of the data as well as the variety of potential analysis techniques that could be used. Thematic analysis was chosen as a primary analysis technique as it allowed the data analysis to be guided by the specific research questions, which provided the framework for this work. Taking this approach allowed patterns to be identified within the data, however there were also a number of shortcomings to using this technique.

Due to the ethical issues related to the sharing of videos of vulnerable individuals it was not possible to provide the full data set to an independent coder, which restricted the extent to which the inter-coder reliability could be established. The coding process was also a very subjective one due to the difficulties in interpreting the connection between children's intentions and their outward behaviours. The coding process was guided by knowledge of the individual children's characteristics built up over time through working with the children and their teachers as well as expertise in areas such as PD, autism and collaboration. It would be unfeasible for another coder to conduct the analysis in the same way due to this specific combination of factors impacting the analysis process. One way to resolve this issue may be to invite other adults who participated within the design team to also contribute to the analysis process, though this was not possible within this work and would also require further time commitment on their behalf.

9.4 Conclusion

Recent technological advances have the potential to offer many benefits to the lives of children with ASD. Many of these children struggle on a daily basis to deal with confusing situations and unclear social expectations, as the following quote about their chosen game design from two of the children who participated within ASD team 2 illustrates:

> *M4: "This game makes no sense"*
> *M3: "Dude life doesn't make sense"*
> *M4: "Exactly"*

Technology removes social demands and provides a learning environment that can be adapted to best meet the needs of each child. However, neurotypical adult designers who cannot be expected to comprehend the extent of the difficulties experienced by a child with ASD and the resulting implications in terms of their needs and preferences are developing much of this technology. This thesis argues for the inclusion of children with ASD within the technology design process through a PD method specifically developed for an ASD population.

This work has advanced the field by highlighting the contributions children with ASD can make to the technology design process, providing a new PD method to best support their involvement within the process and furthering the understanding of the ability of children with ASD to collaborate within a PD context. This has been achieved through the establishment of the children's ability to undertake typical design activities as well as to participate within a collaborative design environment through a series of field experiments and questionnaire studies. The key message of this thesis reflects the belief of Happé and Ronald (2008) that a "one treatment fits all" approach is likely to produce "mixed results". It is essential to appreciate the vast individual differences within the ASD population and to allow opportunities for both the PD methods and the resulting technologies aimed at children with ASD to be fully customisable and tailored to the specific needs of individuals.

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Appendix A

Analysis of Existing Design Methods and Techniques

This appendix contains the detailed analysis for each of the chosen existing design methods and techniques for TD children. The TEACCH-based PD criteria have been applied systematically to each method or technique.

Cooperative Inquiry

- *The Concept of Meaning* - CI incorporates a contextual inquiry activity, which involves the children looking at existing software. This highlights the link between their previous experience of using computer software and what they are designing in the PD session.
- *Focus on Details; Ability to Prioritise the Relevance of Details* - can use adult facilitation to help keep the child on the right track, to reinforce the bigger picture and to help the child generate the appropriate response when working within a team situation.
- *Distractibility* - can be run outside of the classroom in a quiet room with less distraction. Can also tailor the art materials and existing software to be appealing to the child to help keep their attention.
- *Concrete vs. Abstract Thinking* - again the use of contextual inquiry helps give the child concrete examples of what they are being asked to design. The use of art materials also helps them build up something concrete rather than describing their idea verbally.
- *Combining or Integrating Ideas* - CI incorporates an evaluation activity that involves writing down preferences and modifications to existing software, which provides a visual record of elements that could be incorporated into an idea. Also use of craft materials helps everyone get involved in the low-tech prototyping of group idea.
- *Organising and Sequencing* - CI incorporates a number of separate activities that help build up a staged design process that the child can follow more easily than one long activity.
- *Generalisation* - can use adult facilitation to encourage the children to use skills and knowledge previously learned in subjects such as computing and art.
- *Visual vs. Auditory Learning* - all tasks include a visual element such as the use of existing software as well as writing down or drawing all feedback and ideas.
- *Prompt Dependence* – there is no specified way of managing this.
- *Strong Impulses* - can tailor the existing software to incorporate the child's special interests/obsessions in some cases, but not always appropriate.
- *Excessive Anxiety* - there is no specified way of managing this.

Layered Elaboration

- *The Concept of Meaning* - does not include a Contextual Inquiry activity and therefore no way of supporting this is specified.
- *Focus on Details; Ability to Prioritise the Relevance of Details* - no specific adult facilitation is available to support this.
- *Distractibility* - can be run outside of the classroom in a quiet room with less distraction, but does involve coming back together in a large group to discuss ideas which could be distracting for a child with ASD.
- *Concrete vs. Abstract Thinking* - the use of the layered transparencies helps the child visually build up their idea and also provides them with a concrete way of giving feedback on other groups ideas.
- *Combining or Integrating Ideas* - again the use of layered transparencies provides a visual way of integrating different elements of multiple ideas.
- *Organising and Sequencing* - a consistent, iterative process of idea generation is employed to help the children gradually build on their ideas.
- *Generalisation* - no specific adult facilitation available to support this.
- *Visual vs. Auditory Learning* - tasks include a visual element including drawing ideas and feedback.
- *Prompt Dependence* – there is no specified way of managing this.
- *Strong Impulses* - there is no specified way of managing this.
- *Excessive Anxiety* - there is no specified way of managing this.

Mixing Ideas

- *The Concept of Meaning* - Mixing Ideas begins with each child observing how the current system work and an adult explaining that the best way of generating ideas is looking at existing ideas and improving them. This gives the children concrete examples from which to work from. However, it is also suggested that analogies should be used to explain certain concepts, which may be confusing for children with ASD due to their tendency to interpret things literally.
- *Focus on Details; Ability to Prioritise the Relevance of Details* - can use adult facilitation to help keep the child on the right track, to reinforce the bigger picture and to generate the appropriate response when working in groups.
- *Distractibility* - adult works one-on-one with the child to help keep their focus, potential for distractions may increase when collaborating with larger groups of children.
- *Concrete vs. Abstract Thinking* - the use of each child's drawings helps provide concrete representations for their ideas during group discussions. Observing existing systems also helps provide concrete examples of what they are designing.
- *Combining or Integrating Ideas* - Mixing Ideas incorporates a staged collaboration process to gradually introduce the children to integrating their ideas with those of others. The children are encouraged to physically cut out their ideas and combine them with others which allows them to visually see how they are being combined.
- *Organising and Sequencing* - The ideas are generated and developed in a staged process, to help the children first think about their own idea before considering and being influenced by those of others.

- *Generalisation* - can use adult facilitation to encourage the children to use skills and knowledge previously learned in subjects such as computing and art.
- *Visual vs. Auditory Learning* - all tasks are very visual incorporating either observation of existing systems or the child's drawings.
- *Prompt Dependence* – adults undertake an encouragement role, gently elaborate on children's idea where appropriate and the design process is split into smaller highly structured stages to help children understand what is expected of them.
- *Strong Impulses* - there is no specified way of managing this.
- *Excessive Anxiety* - there is no specified way of managing this, but having a qualified adult working one-to-one with the child should mean any anxieties the child is having are recognised and can be dealt with.

Comicboarding

- *The Concept of Meaning* - Comicboarding requires that the children are familiar with the context of comicbooks and some children may find it hard to make the link between this and computer software.
- *Focus on Details; Ability to Prioritise the Relevance of Details* - the high levels of structure involved in this technique can focus the child's attention at the right level of detail and the comicbook style presents a good high-level overview of the child's ideas.
- *Distractibility* - can be run outside of the classroom in a quiet room with less distraction and can tailor the theme of the comicbook to keep the child's attention.
- *Concrete vs. Abstract Thinking* - the comicbook context could be seen as a slightly abstract way of thinking about software design and so may cause problems for children with ASD.
- *Combining or Integrating Ideas* - the artist would be able to provide support for any children struggling to combine or integrate their ideas and make suggestions for how this could be done.
- *Organising and Sequencing* - the use of the comicbook format helps the child organise their idea in a logical sequence. The potentially highly structured nature of the sessions helps the child organise their thoughts into a structured design.
- *Generalisation* - artist can encourage the children to use skills and knowledge previously learned in subjects such as computing and art.
- *Visual vs. Auditory Learning* - technique is very visual and artist can provide support to help child document their ideas visually.
- *Prompt Dependence* – can use the most constrained version of the comic as a prompt for ideas.
- *Strong Impulses* - can incorporate child's interests/obsessions into the theme of the comicbook.
- *Excessive Anxiety* - there is no specified way of managing this.

Bluebells

- *The Concept of Meaning* - the context of the sessions is presented in a detailed way through a variety of mediums, however the use of childhood games may be confusing to children with ASD who are unfamiliar with the games or fail to see the link between the games and software design.
- *Focus on Details; Ability to Prioritise the Relevance of Details* - can use adult facilitation to help keep the child on the right track, to reinforce the

bigger picture and provide one-to-one support in when collaborating with other children to help support them in generating the appropriate response.

- *Distractibility* - can be run outside of the classroom in a quiet room with less distraction.
- *Concrete vs. Abstract Thinking* - uses a mixture of images and narrative from familiar scenarios to explain any abstract concepts. However, again there may be an issue with the use of potentially confusing childhood games within the design process. It is also suggested that analogies could be used to explain certain concepts, which may not benefit the understanding of children with ASD who could interpret them literally. One-to-one support when working with another child can help support them in understanding what the other child is thinking/feeling.
- *Combining or Integrating Ideas* - the design process is separated into four separate activities which helps the child build up different elements of an idea which can then be integrated together in a structured way. Again one-to-one support when working with another child can help support them in understanding what the other child is thinking/feeling.
- *Organising and Sequencing* - the incorporation of a staged structured design process helps the child to progress consistently throughout the session.
- *Generalisation* - can use adult facilitation to encourage the children to use skills and knowledge previously learned in subjects such as computing and art.
- *Visual vs. Auditory Learning* - all tasks include a paper-based visual activity and require the children to sketch out their idea.
- *Prompt Dependence* – there is no specified way of managing this.
- *Strong Impulses* - no scope to tailor the games, but if this is something that the children enjoy then may help provide an outlet for their interests/obsessions.
- *Excessive Anxiety* - there is no specified way of managing this.

Bonded Design

- *The Concept of Meaning* – the context of the design topic is presented through demonstrating and critiquing existing systems
- *Focus on Details; Ability to Prioritise the Relevance of Details* – the design of the new system is split into designing different elements, providing the child with guidance as to what to focus on. A whiteboard is also used to show what has been achieved/what needs to be achieved to show children the “bigger picture” and what is important to focus on next.
- *Distractibility* – the sessions are conducted in a quiet room that is separate to the classroom and specific activities such as journaling and game playing are employed when the children become disengaged.
- *Concrete vs. Abstract Thinking* – the incorporate of existing systems and drawing activities helps provide concrete ways of considering the design topic. However, the use of abstract analogies caused issues with some of the younger children and potentially would cause similar issues with children with ASD. Transfers ideas to computer-based prototype to help children imagine more easily what final system will be like.
- *Combining or Integrating Ideas* – adults can facilitate the combining of ideas in appropriate ways, also used craft materials to model individual paper-based ideas into group ideas.
- *Organising and Sequencing* – A whiteboard is used to provide a session map, which includes what has already been achieved and what still needs to be done helping the children understand the sequence of tasks.

- *Generalisation* – can use adult facilitation to encourage the children to use skills and knowledge previously learned in subjects such as computing and art.
- *Visual vs. Auditory Learning* – Regularly incorporates drawing activities throughout the process to help support visual learning.
- *Prompt Dependence* –there is no specified way of managing this.
- *Strong Impulses* – journaling and physical activities can be used to provide children with an "alternative channel for their energy".
- *Excessive Anxiety* – there is no specified way of managing this.

CARSS

- *The Concept of Meaning* – the context of the design topic is presented through demonstrating and critiquing existing systems
- *Focus on Details; Ability to Prioritise the Relevance of Details* – can use adult undertaking 'collaboration facilitator' role to help keep the child on the right track, to reinforce the bigger picture and to help the child generate the appropriate response when working within a team situation. Perform low-tech or high-tech walkthroughs to give an overview of how the whole system will work.
- *Distractibility* – the sessions are conducted in a quiet self-contained room that is separate to the classroom, to reduce interruptions by other pupils and background noise. Also give breaks, intersperse discussion with practical activities or change pace of activities to prevent children becoming tired or bored, which could lead to them becoming distracted.
- *Concrete vs. Abstract Thinking* – the incorporation of existing systems and drawing activities helps provide concrete ways of considering the design topic. Transfers ideas to computer-based prototype to help children imagine more easily what final system will be like.
- *Combining or Integrating Ideas* – adults undertaking 'collaboration facilitator' role can oversee the combining of ideas in appropriate ways, moderating the discussion and providing one-to-one support for children who struggle dealing with criticism.
- *Organising and Sequencing* –incorporates a number of separate activities that help build up a staged design process that the child can follow more easily than one long activity.
- *Generalisation* – can use adult facilitation to encourage the children to use skills and knowledge previously learned in subjects such as computing and art.
- *Visual vs. Auditory Learning* –Incorporates drawing activities, as well as low and high-tech prototypes throughout the process to help support visual learning.
- *Prompt Dependence* –there is no specified way of managing this.
- *Strong Impulses* – can tailor the existing software to incorporate the child's special interests/obsessions in some cases, but not always appropriate.
- *Excessive Anxiety* – facilitator can intervene if any anxiety related to receiving criticism is observed and give the child a choice to receive it.

Appendix B

Ethics Checklist

UNIVERSITY OF BATH

Department of Computer Science

13-POINT ETHICS CHECK LIST

This document describes the 13 issues that need to be considered carefully before students or staff involve other people ("participants") for the collection of information as part of their project or research.

1. *Have you prepared a briefing script for volunteers?*

At the start of the first session the purpose of the project will be explained to the children as well as the types of activities the children will be required to do and that the sessions will be photographed/filmed with the photographs/video recordings stored securely and anonymously and only used for purposes directly related to the research.

2. *Will the participants be using any non-standard hardware?*

No non-standard hardware will be used.

3. *Is there any intentional deception of the participants?*

There is not intentional deception of the participants everything will be explained clearly and any questions answered honestly.

4. *How will participants voluntarily give consent?*

As the children are under the age of 18, consent forms will be sent to their parents/teachers to sign on their behalf.

5. *Will the participants be exposed to any risks greater than those encountered in their normal work life?*

All sessions will be undertaken at the children's school within a classroom and they will not be exposed to any additional risks.

6. *Are you offering any incentive to the participants?*

The children will be rewarded with five minutes play on an iPad, however this will not be used to induce them to take any additional risks.

7. *Are any of your participants under the age of 16?*

Yes, letters will be sent to all the parents of all children involved to explain their role within the project and allow them the opportunity to withdraw their child from the study. Consent for participation will be provided by the school.

8. *Do any of your participants have an impairment that will limit their understanding or communication?*

Yes, some of the participants are diagnosed with autism. However, all of the sessions will be undertaken at the children's school with members of teaching staff present.

9. *Are you in a position of authority or influence over any of your participants?*

It will be ensured that all children are aware they are free to withdraw and if any signs of distress or anxiety are detected a member of staff will be consulted to ensure the child is able to continue with the study.

10. *Will the participants be informed that they could withdraw at any time?*

Yes all of the children will be told they are free to withdraw at the start of the study.

11. *Will the participants be informed of your contact details?*

The schools will be provided with the contact details of at least one member of the project team.

12. *Will participants be de-briefed?*

During the final session it will be explained to the participants what will happen with the data gathered during the study.

13. *Will the data collected from the participants be stored in an anonymous form?*

All of the data will be stored anonymously in a password-protected location on the researcher's laptop computer.

Appendix C

Final Game Survey (Study 2 – Children)

1. **Does the information on the computer make you want to get the answer right?**

Yes	No	Maybe

2. **Does the information on the computer make you want to get the answer wrong?**

Yes	No	Maybe

3. **Does the reward make you want to play the game for a long time or does it make you bored?**

Play for long time	Makes me bored	Not sure

4. **Do you like the way the game looks? Pick one of the faces to say how much you like or dislike it.**

Awful Not very good Good Really good Brilliant

5. **Do you like the sounds? Pick one of the faces to say how much you like or dislike it.**

Awful Not very good Good Really good Brilliant

6. **Do you like the way the different parts of the game move? Pick one of the faces to say how much you like or dislike it.**

7. **How much do you like all of the game? Pick one of the faces to say how much you like or dislike it.**

8. **Is the game the way you wanted it to be?**

Yes	No	Maybe

9. **If you could change anything what would you change? Tick as many as you want to.**

Colour	Background	Sound	Movement
Information/Feedback	Reward	Something Else	Nothing

10. **Why would you change it?** *(Note down which feature it refers to)*

Don't like it	Have a better idea	Don't know

11. **Would you choose to play it?**

Yes	No	Maybe

12. **Would you tell a friend to play it?**

Yes	No	Maybe

Participation Experience Survey (Study 2 – Children)

1. **How much did you like the activity of helping to design a maths game? Pick one of the faces to say how much you like or dislike it.**

2. **How much did you like working with the rest of the team? Pick one of the faces to say how much you like or dislike it.**

3. **If you could choose who would you prefer to design the game with?**

The team	On my own

4. **How much did you like the part of the activity of thinking up your own ideas? Pick one of the faces to say how much you like or dislike it.**

5. **How much did you like drawing your ideas on paper? Pick one of the faces to say how much you like or dislike it.**

6. **How much did you like talking about your ideas to the rest of the team? Pick one of the faces to say how much you like or dislike it.**

7. **How much did you like seeing the group's ideas on the computer? Pick one of the faces to say how much you like or dislike it.**

8. **How much did you like using the iPad? Pick one of the faces to say how much you like or dislike it.**

9. **Would you take part in the sessions again if you could?**

Yes	No	Maybe

10. **Would you tell a friend that they should take part?**

Yes	No	Maybe

11. **Do you think adults should always ask children about computer games/programs that are being designed for them?**

Yes	No	Sometimes

Final Game Survey (Study 3 – Children)

1. Do you like the way the game looks?

Pick one of the faces to say how much you like or dislike it.

2. Do you like the sounds?

Pick one of the faces to say how much you like or dislike it.

3. Do you like the way the different parts of the game move?

Pick one of the faces to say how much you like or dislike it.

4. How much do you like the whole game?

Pick one of the faces to say how much you like or dislike it.

5. Is the game the way you wanted it to be?

Yes	No	Maybe

6. If you could change anything what would you change and why?

7. Would you choose to play it?

Yes	No	Maybe

8. Would you tell a friend to play it?

Yes	No	Maybe

Participation Experience Survey (Study 3 – Children)

1. How much did you like the activity of helping to **design** a maths game? (i.e. coming up with and drawing ideas)

Pick one of the faces to say how much you like or dislike it.

Awful	Not very good	Good	Really good	Brilliant

2. How much did you like the activity of helping to **build** (in Scratch) a maths game?

Pick one of the faces to say how much you like or dislike it.

Awful	Not very good	Good	Really good	Brilliant

3. If you could choose would you prefer to just design the game (and for someone else to build it afterwards) or to design and build the game during the sessions?

Just design	Design and build

4. How much did you like working with the rest of the team?

Pick one of the faces to say how much you like or dislike it.

Awful	Not very good	Good	Really good	Brilliant

5. How easy or difficult did you find working with the rest of the team?

Difficult	OK	Easy

6. Do you think your team was a successful team or an unsuccessful team?

Pick one of the faces to say how good or bad the team was.

7. Do you think working with other people improved the final game?

Yes	No	Maybe

8. If you could choose who would you prefer to design and build the game with?

The team	On my own

9. How much did you like playing the maths games on the iPad?

Pick one of the faces to say how much you like or dislike it.

10. How much did you like learning to use Scratch? Pick one of the faces to say how much you like or dislike it.

11. Would you choose to use Scratch again?

Yes	No	Maybe

12. Would you take part in the sessions again if you could?

Yes	No	Maybe

13. Would you tell a friend that they should take part?

Yes	No	Maybe

14. Do you think there should have been more or less sessions?

More	Same Number	Less

15. Do you think adults should always ask children about computer games/programs that are being designed for them?

Yes	No	Sometimes

16. Do you think children should be taught to build their own computer games/programs?

Yes	No	Maybe

Teacher Survey Results (Study 2)

ASD Team 1

Teacher Survey

1. **Do you think the children were happy or not happy to take part in the design sessions?**

Happy	Not Happy	Indifferent

Why do you think this?

Because they are still asking now when there going to go out with Dr Emma & Laura again. They also would of showed me there displeasure if they didn't want to do it.

2. **Do you think the children benefitted or did not benefit from taking part in the sessions?**

Benefit	No Benefit	Not Sure

Why do you think this?

It taught all the child a new skill. M: To wait & take his turn in conversations C: To compromise her ideas & T: Gained confidence to voice his opinion

3. **What do you think the children learned from the experience? E.g. in terms of knowledge, team work, soft skills**

All the above in number 2 but it was also a big confidence boost for all 3 to be part of something & see there own idea develop.

4. **What do you think the most positive aspect(s) of the session was?**

All the sessions were positive but I think it was watching there confidence grow & the relationship between the children & different adults grow, which was done by each session seeing there ideas come to life & that the adults listened & took on board what they said.

5. **Is there anything that you would suggest we could change/improve upon for future sessions?**

I Think the way the Session were structured, visual & recapped was brilliant! There was visual examples for them to get ideas from but not copy which made them use there imagination. I don't think there was anything that needed improving, apart from making sure we asked M.P direct questions otherwise he always said no! but i'm still forgetting to do that everyday

6. **After taking part in these sessions is there anything that you would say you learned or would have an impact on your teaching in any way?**

I think the way you structed the white board & recapped every-thing is a really good mature way to make lessons for higher ability Students with autistic Spectrum disorders appear & be more mature & it made them feel less different then when we use PEC with them ~~higher ability Students~~.

7. **Do you have any other feedback or comments on the sessions?**

Only that it was brilliant, fun, insightful & Something I was proud to be part of and I know the students felt the Same way & we all miss the IPad! (and of Course Dr Emma & Laura).

We would like to take this opportunity to thank you for taking part in our project, your help and support has been invaluable to us. We welcome any feedback (both positive and negative) that you can share with us.

ASD Team 2

Teacher Survey

1. **Do you think the children were happy or not happy to take part in the design sessions?**

Happy	**Not Happy**	**Indifferent**

Why do you think this?

They all Joined in

2. **Do you think the children benefitted or did not benefit from taking part in the sessions?**

Benefit	**No Benefit**	**Not Sure**

Why do you think this?

They got to do something they enjoyed and could be part of the process.

3. **What do you think the children learned from the experience? E.g. in terms of knowledge, team work, soft skills**

Better team work.

4. **What do you think the most positive aspect(s) of the session was?**

Team work. Actually doing work when the boys saw it as fun

5. **Is there anything that you would suggest we could change/improve upon for future sessions?**

No. All really good

6. **After taking part in these sessions is there anything that you would say you learned or would have an impact on your teaching in any way?**

NO

7. **Do you have any other feedback or comments on the sessions?**

I think the boys really enjoyed it and it broke up there working week with something creative.

We would like to take this opportunity to thank you for taking part in our project, your help and support has been invaluable to us. We welcome any feedback (both positive and negative) that you can share with us.

TD Team 1

Teacher Survey

1. Do you think the children were happy or not happy to take part in the design sessions?

Happy	Not Happy	Indifferent

Why do you think this?

They enjoyed being part of a Team

2. Do you think the children benefitted or did not benefit from taking part in the sessions?

Benefit	No Benefit	Not Sure

Why do you think this?

It helped them to engage with other Students who were from different communities

3. What do you think the children learned from the experience? E.g. in terms of knowledge, team work, soft skills

How to respect each other's views and idea's, helping them to deside as a Team

4. What do you think the most positive aspect(s) of the session was?

Working as a Team, knowing that they were creating something different which would be played

5. **Is there anything that you would suggest we could change/improve upon for future sessions?**

'All Good'

6. **After taking part in these sessions is there anything that you would say you learned or would have an impact on your teaching in any way?**

The boundaries and rules which were set out made it easy for the young people to follow, as they were incharge of tidying each task. I feel they owned the sessions, I am now using this in Group sessions

7. **Do you have any other feedback or comments on the sessions?**

The organisation punctuality and interaction myself with 'BEC' made it a pleasure to be part of - the Y/P gained many skills and myself which will help them and myself in the future.

We would like to take this opportunity to thank you for taking part in our project, your help and support has been invaluable to us. We welcome any feedback (both positive and negative) that you can share with us.

TD Team 2

Teacher Survey

1. **Do you think the children were happy or not happy to take part in the design sessions?**

Happy	Not Happy	Indifferent

Why do you think this?

Enjoyable sessions, out of their normal lessons.

2. **Do you think the children benefitted or did not benefit from taking part in the sessions?**

Benefit	No Benefit	Not Sure

Why do you think this?

Opportunity to work in a small group & discuss their ideas

3. **What do you think the children learned from the experience? E.g. in terms of knowledge, team work, soft skills**

Working in a group. Listening to others coming up with ideas of their own.

4. **What do you think the most positive aspect(s) of the session was?**

They felt part of a team. They enjoyed having their ideas heard.

5. **Is there anything that you would suggest we could change/improve upon for future sessions?**

—

6. **After taking part in these sessions is there anything that you would say you learned or would have an impact on your teaching in any way?**

It highlighted the benefits of small group work.

7. **Do you have any other feedback or comments on the sessions?**

Enjoyable sessions. Was great working with such a small group!

We would like to take this opportunity to thank you for taking part in our project, your help and support has been invaluable to us. We welcome any feedback (both positive and negative) that you can share with us.

Teacher Survey Results (Study 3)

ASD Team 2

Teacher Survey

1. **Do you think the children were happy or not happy to take part in the design sessions?**

Happy	Not Happy	Indifferent

Why do you think this?

Computer games are a big part of children's lives nowadays, the boys in this group found learning how to produce a game really intresting & fun.

2. **Do you think the children benefitted or did not benefit from taking part in the sessions?**

Benefit	No Benefit	Not Sure

Why do you think this?

Something new & exciting.

3. **What do you think the children learned from the experience? E.g. in terms of knowledge, team work, soft skills**

Computer skills
learned alot about Scratch
Develops social skills eg. team work.

4. **What do you think the most positive aspect(s) of the session was?**

THE final product, the boys got to see there work.

5. **Is there anything that you would suggest we could change/improve upon for future sessions?**

? NO I dont think so

6. **After taking part in these sessions is there anything that you would say you learned or would have an impact on your teaching in any way?**

NO.

7. **Do you have any other feedback or comments on the sessions?**

Really well executed boys enjoyed sessions as they were all different each session was always on the board, and Ticked off as went along.

We would like to take this opportunity to thank you for taking part in our project, your help and support has been invaluable to us. We welcome any feedback (both positive and negative) that you can share with us.

ASD Team 3

Teacher Survey

1. **Do you think the children were happy or not happy to take part in the design sessions?**

Happy	Not Happy	Indifferent

Why do you think this?

Because the boys enjoy Video Games and Interacted well

2. **Do you think the children benefitted or did not benefit from taking part in the sessions?**

Benefit	No Benefit	Not Sure

Why do you think this?

Good interaction
Team building
Fun

3. **What do you think the children learned from the experience? E.g. in terms of knowledge, team work, soft skills**

Some boys had No Knowledge on Scratch At All.
To Share

4. **What do you think the most positive aspect(s) of the session was?**

Building a game the boys could See the finished product.

5. **Is there anything that you would suggest we could change/improve upon for future sessions?**

/

6. **After taking part in these sessions is there anything that you would say you learned or would have an impact on your teaching in any way?**

Group / Team work is Possibe.

7. **Do you have any other feedback or comments on the sessions?**

Emma & Laura were really good with the Students & made allowances with each boys behaviour.

We would like to take this opportunity to thank you for taking part in our project, your help and support has been invaluable to us. We welcome any feedback (both positive and negative) that you can share with us.

TD Team 2

Teacher Survey

1. **Do you think the children were happy or not happy to take part in the design sessions?**

Happy	Not Happy	Indifferent

Why do you think this?

They enjoyed designing the game.

2. **Do you think the children benefitted or did not benefit from taking part in the sessions?**

Benefit	No Benefit	Not Sure

Why do you think this?

Learnt some new programming skills.
Worked together as a small group.

3. **What do you think the children learned from the experience? E.g. in terms of knowledge, team work, soft skills**

- Working as part of a group with pupils from different years.
- Programming / using scratch.

4. **What do you think the most positive aspect(s) of the session was?**

- They felt "chosen" to take part - Good for confidence
- Working as a small group.

5. **Is there anything that you would suggest we could change/improve upon for future sessions?**

6. **After taking part in these sessions is there anything that you would say you learned or would have an impact on your teaching in any way?**

Although not always possible, it's nice to mix different age groups and get them to work together.

7. **Do you have any other feedback or comments on the sessions?**

We would like to take this opportunity to thank you for taking part in our project, your help and support has been invaluable to us. We welcome any feedback (both positive and negative) that you can share with us.

TD Team 3

Teacher Survey

1. **Do you think the children were happy or not happy to take part in the design sessions?**

Happy	**Not Happy**	**Indifferent**

Why do you think this?

- They enjoy working on skratch.
- Missing lessons.

2. **Do you think the children benefitted or did not benefit from taking part in the sessions?**

Benefit	**No Benefit**	**Not Sure**

A little

Why do you think this?

- An activity different to normal lessons which is great.
- Missing 6 normal lessons may be a problem for some teachers/pupils.

3. **What do you think the children learned from the experience? E.g. in terms of knowledge, team work, soft skills**

Working well as a team.

Working with adults other than their usual teachers.

4. **What do you think the most positive aspect(s) of the session was?**

- Learning new work - scratch
- Working as a small group - having their ideas listened to.

5. **Is there anything that you would suggest we could change/improve upon for future sessions?**

—

6. **After taking part in these sessions is there anything that you would say you learned or would have an impact on your teaching in any way?**

It was nice working in a mixed year group (years 8 and 9)

7. **Do you have any other feedback or comments on the sessions?**

/

We would like to take this opportunity to thank you for taking part in our project, your help and support has been invaluable to us. We welcome any feedback (both positive and negative) that you can share with us.

Appendix D

Scratch Tutorial

Interface explanation

- Differently coloured menus, containing different actions such as moving the images or playing a sound.
- Drag and drop action block into script area to make game do things.
- This window is where the game is displayed and you can test what you have done so far. Green flag starts game and red circle stops game.
- This window contains sprites, which are the moving parts of the game and you assign them actions in the script window.
- Also extra buttons at the top that allow you to duplicate, cut, and resize different parts of your game.

Change Sprite

- To change the ball, click on the ball in the Sprite window.
- Click on the costumes tab.
- Click on 'Import' > Things and then choose a different ball to use.
- You can even take a picture using the camera and incorporate it into your game or draw your own ball.
- Press 'x' to remove other ball.

Change Background

- Click on 'Stage' and then 'Background' tab.
- Click on 'edit' > import and then 'Nature' choose a background.
- Replace red bar at bottom.
- Click on 'Ok'.

Add Menu

- Create menu screen by clicking on 'Stage' and 'Backgrounds' tab.
- Click on paint button and draw menu – pick background colour and add game title.
- Click OK and name background 'gameMenu'.
- Add start button by drawing a new Sprite.
- Import button from Costumes > Things.
- Increase size of button.
- Add text 'Play game' to button and click OK.
- Name button 'playButton'.
- Add script - when playButton clicked – broadcast startGame – hide.
- Add script – when flag clicked – show.
- Go to background, add script – when I receive startGame – switch to background red bottom.
- Add script – when flag clicked – switch to background gameMenu.
- Click on ball and add script – when I receive startGame – to each script block.

- Add script – show – to first script block.
- Add script – when flag clicked – hide.
- Do same for paddle.
- Test game.

Change Graphic Effect
- Click on 'ball'
- Add in script – change color effect by 25 – after the script forever if touching paddle.
- Test Game.

Speech Bubbles
- Go to paddle
- After show add script – forever if (touching ball) – say nice shot for 1 sec.

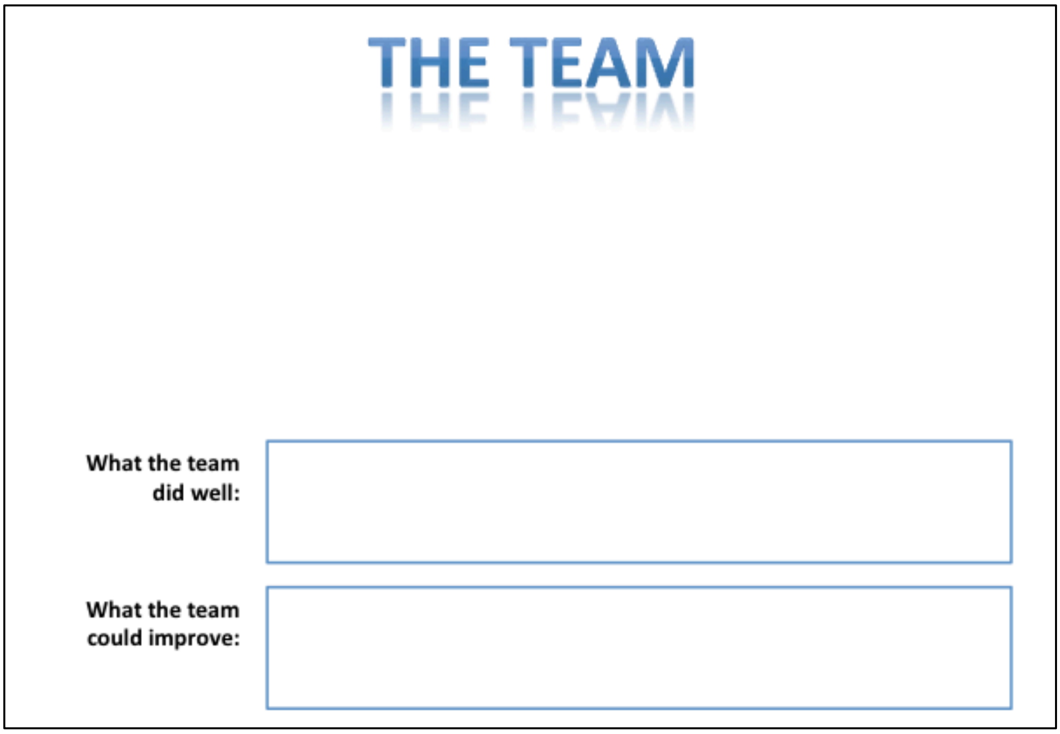
Add Sprite/Timer/New Level
- Duplicate ball
- Rename to 'ball2'.
- Add script – wait until ((timer) > 10) – show - after first when I receive block.
- Go to playButton click tickbox to show timer and add script – reset timer – after broadcast startGame script block.
- Test Game

Sound Effects/Music
- Go to 'ball2'
- Click on 'Sounds' tab.
- Import sound from Effects > Rattle.
- Delete waterdrop sound.
- Go to 'Scripts' tab.
- Change - play sound - script to 'Rattle'.
- Test Game.
- Click on Stage.
- Go to 'Sounds' tab.
- Click on Import and choose Music Loops > Drum Machine.
- Click on 'Scripts' tab and add – forever – play sound DrumMachine until done after – switch to background red bottom.
- Test Game.

Keep Score
- Click on Variables
- Click on 'Make a Variable', call it 'Score' and make it available for all sprites.
- Click on the checkbox to display the score on screen.
- Click on Stage and add script – set score to 0, after – when I receive startGame.
- Click on ball and add script – change score by 1 – after forever if touching paddle.
- Click on ball2 and add script – change score by 2 – after forever if touching paddle.
- Test Game.

Appendix E

Display of Work Templates (Study 3)


THE TEAM

What the team did well:

What the team could improve:

THE ACTIVITIES

Activities enjoyed the most and why:

Activities enjoyed the least and why:

What was learnt:

FINAL GAME

What is good about the game:

What needs to be improved:

OUR IDEAS

Which ideas were good:		Which ideas were not so good:	
Difficulty of thinking of ideas:		Difficulty of combining ideas:	

Appendix F

Collaboration Coding Scheme

COMMUNICATION

Verbal Utterances		
1A	Direction	Tells another group member what to do
1B	Question	Asks another group member for example to provide further explanation, confirmation, preference or repeat their utterance
1C	Disagreement	Voices opposition to idea/action of another group member
1D	Repairs (Successful/Unsuccessful)	Attempts to verbally resolve breakdown/conflict within group
1E	Acceptance	Verbally agrees with an idea/action of another group member
1F	Narration	Provides verbal commentary of actions
1G	Digression	Discusses topic not directly related to task
1H	Suggestion	Proposes an idea/action
1I	Opinion	Shares own view on the idea/action of another group member
1J	Clarification	Provides further explanation/repetition of directions or in answer to another group member's question
1K	Encouragement	Provides verbal reassurance, praise or motivation for other group members
1L	Statement	Makes a statement related to reinforce their role within the task, the current status of the task or to indicate their understanding of the task
1M	Socially-Distributed Productions	Completes the sentence or idea of another group member

1N	Negotiate	Discusses ways to resolve differences in ideas/actions
2	**Written Messages**	Communicates ideas by writing down on paper
3	**Gestural Messages**	Communicates ideas solely by using gestures such as pointing or miming
4	**Deictic Messages**	Communicates ideas by simultaneously using spoken language and gestures

5	**Awareness**	
5A	Monitoring of actions and intentions	Allows other group members to monitor actions/intentions by providing a running verbal commentary of actions or thought processes
5B	Awareness of resources	Attempts to establish a common understanding of a resource used by the group through gestures or verbal discussion
5C	Awareness of other's actions/body language	Demonstrates an awareness of other group members based on their actions or body language
5D	Awareness of need for assistance	Demonstrates awareness of another group member experiencing difficulties and attempts to provide some form of additional help

COORDINATION

6	**Coordination of Resources**	
6A	Obtain Resource	Asks another group member for a resource or takes an object from another area of the group workspace
6B	Reserve Resource	Claims ownership of resource by positioning it or marking it in a certain way
6C	Protect Work	Stops other group members from interfering with a resource in some way
6D	Resource Transfer	Gives a resource directly to another group member or places a resource in front of another group member
6E	Resource Deposit	Places an resource in the shared workspace to make it available for all group members
6F	Negotiation of Resources	Establish ownership of resource through verbal discussion
7	**Coordination of Roles**	Attempts to establish a shared understanding of each group member's role within the task or to renegotiate roles

8	**Coordination of Actions**	Performs action based on the actions of other group members i.e. turn-take if only one group member can access a resource at a time